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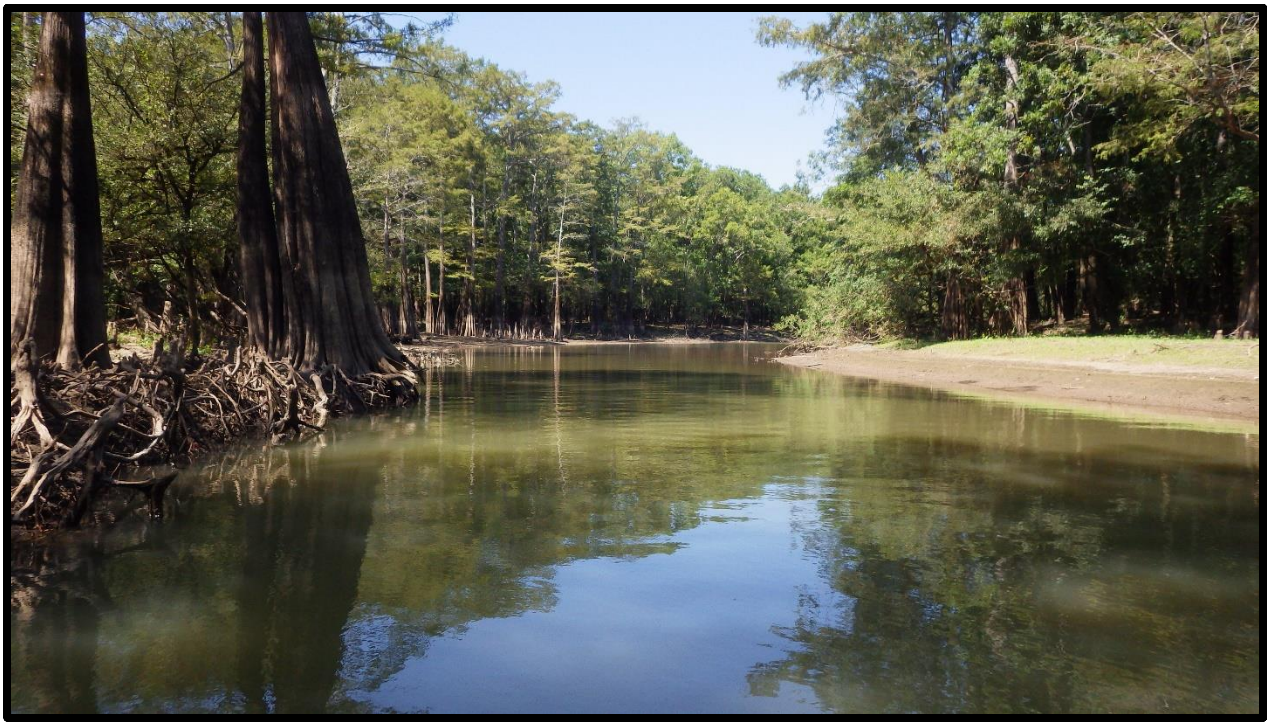

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Prepared by: John L. Harris

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Freshwater Mussel Survey of Major Tributaries in Dale Bumpers White River National Wildlife Refuge

Principal Investigator: John L. Harris
Welch/Harris, Inc.
10846 Plantation Lake Road
Scott, AR 72142

ABSTRACT

Qualitative timed-search sampling was conducted to determine freshwater mussel species richness and relative abundance, and the location of high-density mussel assemblages (mussel beds) for four major tributary streams within Dale Bumpers White River National Wildlife Refuge located in Arkansas, Desha, Monroe, and Phillips counties, Arkansas. In Maddox Bay, 73 sample sites produced 3,088 live individuals representing 28 native species. *Quadrula* and *Amblema plicata* were the dominant species accounting for 22% and 19.3% of total mussels, respectively. Ten high density mussel assemblages greater than 500 m^2 were defined in the Maddox Bay survey area. In Indian Bayou, 2,442 specimens of 29 species were collected from 38 sample sites, and four species, *Fusconaia flava* (16.4%), *Cyclonaias pustulosa* (14.8%), *Amblema plicata* (13.7%), and *Plectomerus dombeyanus* (12.9%) were co-dominant representing ~58% of live individuals. Seven mussel beds were defined in the Indian Bayou survey area, although mussels occurred almost continuously throughout Indian Bayou. Big Island Chute (also known as White River Chute) was sampled at 80 sites, and 2,284 specimens representing 26 species were examined. The dominant species were *Quadrula quadrula* (23.7%) and *Cyclonaias pustulosa* (19.9%), and 11 mussel beds were defined in Big Island Chute. *Quadrula quadrula* was the dominant species in LaGrue Bayou representing 40.5% of the 2,598 total specimens collected. Twenty-three native species were found in LaGrue Bayou, and seven mussel beds were located and defined.

The Arkansas mussel species of greatest conservation need (SGCN) found during the survey included *Obovaria olivaria* (17 specimens from 16 sample sites), *Quadrula apiculata* (183 specimens, 92 sites), *Q. nobilis* (272 specimens, 105 sites), *Toxolasma texasiense* (14 specimens, 11 sites), *Truncilla doncaciformis* (17 specimens, 15 sites), *Uniomerus declivis* (1 relict specimen, 1 site), and *Villosa lienosa* (1 specimen, 1 site). Overall, 35 mussel beds were located, and their areas estimated, and the largest was 16,500 m^2.

INTRODUCTION

The mussel fauna of the White River has been of great interest to malacologists since the early 1900s, and it supported a viable commercial mussel fishery during this time period (Brann 1947, Arkansas Game and Fish Commission 1991-1999). Coker (1919) reported that the White River yielded shell and pearl products totaling approximately $123,000 during 1912, which ranked it fourth in the United States in terms of commercial production for the period 1912-1914. During the 1990s, commercial harvest of mussels continued in the White River, and the annual yield has been variously reported to represent from 10-40 percent of the total poundage harvested in Arkansas (AGFC 1991-1999). In 1996, the total White River mussel harvest was valued at approximately $385,000. During this same period, White River tributaries Maddox Bay and LaGrue Bayou also figured prominently in AGFC mussel harvest reports.

Freshwater mussel species richness, abundance, and distribution are poorly known from major tributaries to the White River within Dale Bumpers White River National Wildlife Refuge (NWR). Available information regarding White River NWR mussels comes primarily from Gordon et al. (1994), Christian (1995), and Harris and Christian (2000). The Comprehensive Conservation Plan for White River NWR (U.S. FWS 2012) listed the objective to inventory mussels, but none of the primary tributaries within the refuge have been systematically surveyed to determine the mussel species present, their relative abundance, and their distributions within these streams. Without data on which species are found on the refuge or whether threatened and endangered species exist in major White River tributary streams, the refuge cannot adequately protect or manage for them.

The objectives of this project were: 1) Locate and map mussel beds in a subset of the major waterways and tributaries of the lower White River located on Dale Bumpers White River National Wildlife Refuge. This subset included 8.5 miles of Indian Bayou, 14.5 miles of Maddox Bay, 8.25 miles of LaGrue Bayou and 13.75 miles of White River Chute (Figure 1), and 2) Document all freshwater mussel species encountered within this 45-mile subset of the major tributaries.

STUDY AREA

<u>Maddox Bay</u> – is described as a chute system by Buchanan (1998), and it diverges from the White River as Cut Bluff Slough at approximately White River Mile 80 and reconnects at approximately White River Mile 65.6 in Maddox Bay Bend. The entirety of the Maddox Bay chute from divergence to reconnection is approximately 26.88 stream kilometers (16.7 stream miles). Major tributaries joining Maddox Bay include Green Bayou (also known as Green River), Dial Creek, and Adams Bayou. Indian Bayou diverges from Maddox Bay taking approximately half of the discharge on a separate pathway to the White River. Maddox Bay morphology varies substantially within the study area ranging from narrow and shallow with moderately swift current velocity at the upstream and downstream ends to relatively wide and deep with no visible current velocity through much of the middle portion.

Indian Bayou – is approximately 19.3 stream km (ca. 12 stream mi) long and the United States Geological Survey (USGS) classifies it as a distinct drainage system with a 103 km2 drainage area that includes Indian Bay (Sullavan 1974). As previously detailed, Indian Bayou diverges from Maddox Bay and proceeds to its confluence with Indian Bayou and White River. In years of normal or high rainfall, water from the White River flows through Indian Bayou year-round. Indian Bayou is the smallest of the White River tributaries in this study, and it is relatively narrow and shallow with current velocity ranging from slow to swift but present throughout.

Big Island Chute – also known as White River Chute, diverges from White River at approximately River Mile 53.4 and reconnects at White River Mile 38.7. Big Island Chute is approximately 22.1 stream km (13.7 stream mi) long and major tributaries include Panther Branch, Hurricane Bayou, and Essex Bayou. Big Island Chute is moderately wide and deep in most sections and current velocity ranges from swift at the upstream divergence from the White River to not visible at the downstream reconnection to the White River.

LaGrue Bayou – originates east of Carlisle near U.S. Highway 70 and flows southeasterly approximately 147.7 stream km (91.8 stream miles) through Prairie, Monroe, and Arkansas counties before emptying to the White River at approximately River Mile 17 near Jacks Bay. Near the headwaters, LaGrue Bayou was impounded in 1942 to form the 4,000-acre Peckerwood Lake, ostensibly for irrigation purposes. Major tributaries to LaGrue Bayou include Little LaGrue Bayou and Cypress Bayou entering from the west and Essex Bayou entering from the east. LaGrue Bayou is similar to Big Island Chute in that it is moderately wide and deep throughout, but its current velocity is slow to not detectable throughout the study area.

METHODS

Species Richness, Distribution, Qualitative Sampling

Sample methods were established during a series of Arkansas State University Master of Science thesis projects (Rust 1993, Christian 1995, Posey 1997, Davidson 1997) surveying freshwater mussels in large rivers in Arkansas. Sample methodology in this project generally follow those used by Harris et al. (1994), Christian (1995), Davidson (1997), and Christian and Harris (2005). Survey methods generally consistent for each water body are as follows:

Timed searches of probable mussel bed habitats were most often conducted by diving using surface supplied air or less often, in shallow water less than 1.0 m deep, by snorkeling or wading. The diver/snorkeler/wader searched across the stream in “transects” approximately 1.0 meter (3.3 feet) wide perpendicular to flow collecting all mussels encountered. Transect searches consisted of an area extending from bank to bank (i.e., wetted channel width) for small steams (<40 m wide) or from inshore to mid-channel (sometimes beyond) for larger streams and generally ranged 30-60 m in length. Each dive search at a sample site consisted of at least two transects beginning inshore or mid-channel and moving out and back across the channel, and each wading/snorkeling search in shallow water consisted of four transects. Survey sites were searched upstream and downstream within high quality stream habitat to identify and determine

the limits of a potential mussel bed. Searchers estimated the number of live mussels encountered per m2 by tactile methods. If the number of mussels was ≥10 mussels/m2, the diver estimated the width of the bed by traversing the width limits in one-meter increments. Additional downstream and upstream "transects" were conducted until the substrate was uninhabited by mussels or density was <10 mussels/m2. Stream reaches inhabited by mussel densities ≥10/m2 were then inferred based on searcher density estimates and CPUE at sample sites, and the length of these high-density reaches was estimated by interpreting stream morphology in conjunction with the sample estimates. Bed length was measured using DeLorme Topo USA 8.0 measure tool and Google Maps in conjunction with coordinates from the initial transect samples.
All mussels encountered were collected and brought to the surface, identified to species, recorded on site specific data sheets that included GPS site coordinates and physical habitat observations, and the mussels replaced in the substrate. Dive locations within the survey area were recorded utilizing a Garmin GPS III Plus global positioning satellite receiver. Water depths were determined with a Humminbird 560 Fishfinder boat mounted depth finder or a Sokkia fiberglass 25-ft depth rod. Channel width was measured using a Nikon PROSTAFF 7i laser rangefinder from the anchored boat or from shore at the water line. The diver provided substrate conditions for each dive site by estimating percent surface substrate composition using the modified Wentworth (1922) Scale.

Voucher specimens collected were fixed and preserved in 95% ethanol and deposited in the Mollusk Collection, Museum of Zoology, Arkansas State University. Nomenclature in the body of this report follows scientific and common names presented by Williams, et al. (2017). Table 1 lists the scientific and common names of mussels found during this study and in previous surveys of the White River within the NWR boundaries (Christian 1995, Harris and Chordas 2000, Harris and Christian 2000, 2003).

Summary statistics for each target stream were compiled using Excel and Systat 9.0. Summary statistics include total mussels collected, percent total mussels, frequency (number of sites where encountered) and percent frequency (of total sites) for each individual species and total mussels. Also, catch per unit effort (CPUE) is reported as the number of live mussels collected per 10 minutes of search time at each sample site.

Due to variation in stream morphology and available mussel habitat, sampling methodologies varied somewhat among the target streams. These methodologies are briefly discussed as follows:

<u>Maddox Bay</u> - mussel concentrations were located by diving perceived high probability areas within the stream based on previous work in the White River (Christian 1995). Surveyors utilized dive techniques with surface supplied air provided by a Brownies hookah rig apparatus supported from a boat mounted dive platform consisting of a 16-foot Weldbilt jon-boat powered by a 30-horsepower Evinrude outboard motor. The diver was equipped with an AGA full face mask allowing diver to surface communication via Mach II-BUDS (diver) and an Ocean Tech STX 101 surface system. Communication was essential for the field assistant to direct the diver on transects in areas without current velocity and for the diver to provide mussel density, substrate, and bed width data to the assistant. It was considered prudent for this initial Maddox

Bay survey to collect at more or less regular distance intervals along the length of the stream. Mussel concentrations were located by diving the length of the study area at intervals ranging from approximately 200-700 m. Length of the Maddox Bay study area through the refuge was estimated at 21.6 stream kilometers (stream km) (14.5 stream miles, stream mi). An approximately 1.87-km (1.16-mi) long reach of the upstream most portion of Maddox Bay was inaccessible due to treefall and channel blockage preventing boat access, despite multiple attempts to access from the upstream and downstream directions and efforts to clear boat lanes by chainsaw. Paired sample sites were utilized on opposite sides of Maddox Bay in wider locations (>150 m) to assure that mussel beds were not established in atypical habitat (i.e. inside portion of a bendway).

Indian Bayou - surveyors accessed Indian Bayou by 14-foot long Alumacraft jon-boat powered by a 2.5 horsepower Yamaha outboard motor. A smaller surface supplied air system was utilized without diver to surface communications in Indian Bayou. Low water levels and sand deposition from bank to bank in some areas made access extremely difficult using boat transport. Many sites were surveyed by two researchers hand grubbing transects from bank to bank and also walking the stream bank searching among fresh dead shells that had apparently been subject to mammal predation. Length of the Indian Bayou study area was estimated at 13.7 stream km (8.5 stream mi). Approximately 0.76 stream km (0.47 stream mi) was inaccessible due to treefall and channel blockage preventing boat access, despite attempts to access from both the upstream and downstream directions and efforts to clear boat lanes by chainsaw.

Big Island Chute - mussel concentrations were located by diving perceived high probability areas within the stream based on previous work in the White River (Christian 1995). The larger dive platform and surface supplied air unit with diver communications was utilized in Big Island Chute. The outside portions of bendways and straights in the river were targeted as high probability areas, and sites within these portions of the river were sampled at approximately 100-800 m intervals to define the area occupied by high density mussel concentrations. Mussel beds were defined as occupying areas >500 m2 and with mean densities ≥10 mussels/m2 (Christian and Harris 2005). Length of the Big Island Chute study area was estimated at 29.1 stream km (18.1 stream mi).

LaGrue Bayou - mussel concentrations were located by diving the length of the study area at intervals ranging from approximately 200-500 m. The larger dive platform and surface supplied air unit with diver communications was utilized in LaGrue Bayou. Bendways and straights in LaGrue Bayou were not appreciably different morphologically (depth, substrate), a condition similar to the Cache River, AR (Christian 1995, Christian et al. 2005). Therefore, it was considered prudent for this initial LaGrue survey to sample at more or less regular intervals throughout its length. Due to its relatively narrow width, many LaGrue Bayou sites were sampled from bank to bank with a minimum of two transects per survey site. Length of the LaGrue Bayou study area through the refuge was estimated at 13.3 stream km (8.25 stream mi).

RESULTS

Maddox Bay - Five field days were spent during August and September 2018 sampling 73 sites for mussels in Maddox Bay (Figures 2, 2-1, 2-2). Approximately 16.4-person hours were spent conducting dive and wading searches. A total of 3,088 live individuals representing 28 species was examined, and live mussels were encountered at all 73 sample sites (Table 2, Appendix A). *Quadrula quadrula* was the dominant species accounting for 22.0% of the live mussels sampled, and it was found at 68 of 73 sample sites (93.2%). *Amblema plicata* was also common and widespread in Maddox Bay with 596 individuals collected representing 19.3% of the total catch, and it was found at 66 of 73 sample sites (90.4%). Catch per unit effort ranged from 5.0 – 71.5 mussels/10 minutes search time with mean CPUE 31.4 mussels per 10 minutes. Ten areas larger than 500 m2 were delineated as high-density mussel assemblages (beds) (Figure 3, Table 3), and they were categorized as small (500-1000 m^2, n = 2), medium (1K-10K m^2, n = 7) or large (10K-30K m^2, n = 1) after Harris (2017). Mean bed area was 4,085 m2 with a range of 750 - 16,500 m2. CPUE for sample sites associated with mussel beds generally was >30 but ranged from 20 – 71.5. Several of Arkansas species of greatest conservation need (SGCN) were found in Maddox Bay including *Obovaria olivaria* (1 specimen from 1 site), *Quadrula apiculata* (48 specimens, 27 sites), *Q. nobilis* (41 specimens, 23 sites), *Toxolasma texasiense* (13 specimens, 10 sites), and *Truncilla donaciformis* (3 specimens, 3 sites). A summary table and field data sheets for Maddox Bay sample sites are in Appendix A.

Indian Bayou - Four field days were spent from August through October 2018 sampling 38 sites in Indian Bayou (Figure 4). Search time totaled 15.9-person hours in the bayou. Live mussels were abundant and easy to find with 2,442 individuals representing 28 species collected, and an additional species, *Uniomerus declivis,* was represented by one relatively recently deceased shell (Table 5). Live mussels were encountered at all 38 sample sites, and CPUE ranged from 3.0-64.5 per 10 minutes search time with a mean of 25.6. Four species individually comprised more than 10% of mussels sampled, and these included *Fusconaia flava* (16.4%), *Cyclonaias pustulosa* (14.8%), *Amblema plicata* (13.7%), and *Plectomerus dombeyanus* (12.9%). Arkansas SGCN occurring in Indian Bayou included *Quadrula apiculata* (8 specimens, 6 sites), *Q. nobilis* (13 specimens, 8 sites), *Toxolasma texasiense* (1 specimen, 1 site), *Truncilla donaciformis* (6 specimens, 5 sites), and *Villosa lienosa* (1 specimen, 1 site). Seven mussel beds were delineated in Indian Bayou, 1 categorized as small sized and the remaining six as medium (Table 4, Figure 5). Mean bed area was 5,057 m2 with a range of 900 - 9,500 m2. CPUE for sample sites associated with mussel beds generally was >25 but ranged from 17.8 – 64.5 per 10 minutes search time. A summary table and field data sheets for Indian Bayou are in Appendix B.

Big Island Chute - A total of 13.4 dive hours dispersed over five field days in September and October 2018 was spent searching Big Island Chute for mussel beds, and 80 sample sites yielded 26 species from among 2,284 live individuals (Figures 6, 6-1, 6-2, Table 6). Ten sample sites did not yield any live mussels, and CPUE ranged from 0 - 84.0 per 10 minutes search time with a mean of 28.4 for all 80 sites. The dominant species was *Quadrula quadrula* comprising approximately 23.7% of the live mussels examined, and it was closely followed in relative abundance by *Cyclonaias pustulosa* (19.9%). *Cyclonaias pustulosa* was the most widespread species within the survey area occurring at 60 of 80 sample sites (75%), followed by *Quadrula*

quadrula at 73.8%. Arkansas SGCN found in Big Island Chute included *Obovaria olivaria* (16 specimens from 15 sites), *Quadrula apiculata* (66 specimens, 35 sites), *Q. nobilis* (43 specimens, 27 sites), and *Truncilla donaciformis* (4 specimens, 4 sites). Big Island Chute had the greatest number of mussel beds among the survey streams with 11 defined beds, two characterized as small beds and the remaining nine characterized as medium sized (Figure 7, Table 7). Mean bed area was 2,991 m2 with a range of 800 – 9,000 m2. CPUE for sample sites associated with mussel beds generally was >35 but ranged from 20 – 84.0 per 10 minutes search time. A summary table and field data sheets for Big Island Chute are in Appendix C.

<u>LaGrue Bayou</u> - Four field days in August 2018 were spent sampling 58 sites in LaGrue Bayou, and total dive time searching for mussels was 11.8 hours (Figures 8, 8-1, 8-2). A total of 2,598 live individuals distributed among 23 species was collected (Table 9), and CPUE ranged from 0-78.1 per 10 minutes search time with a mean of 36.6 for all 58 sites. The dominant species was *Quadrula quadrula* (40.5%), and *Amblema plicata* (13.0%) was the only other species contributing more than 10% of the sample total. Live mussels were found at 56 of 58 (96.6%) sample sites, and the most widely distributed species in the LaGrue Bayou study area were also *Quadrula quadrula* (54 of 58 sample sites, 93.1%) and *Amblema plicata* (50 of 58, 86.2%). In addition, several AR SGCN were found in LaGrue Bayou including *Quadrula apiculata* (61 specimens from 24 sample sites), *Q. nobilis* (175 specimens, 47 sites), and *Truncilla donaciformis* (4 specimens, 3 sites). Seven mussel beds were defined in LaGrue Bayou, two characterized as small (<1000 m2) and the remaining five characterized as medium-sized (Figure 9, Table 8). Mean bed area was 2,489 m2 with a range of 525 - 5000 m2. CPUE for sample sites associated with mussel beds generally was >40 but ranged from 20 – 78.1. A summary table and field data sheets for LaGrue Bayou are in Appendix D.

DISCUSSION

<u>Maddox Bay</u> – stream morphology was of two distinctly different types: narrow and flowing (lotic) or wide and lake-like (lentic). Although mussels were consistently found in both habitat types, mussel beds were more commonly found in the narrow lotic habitats at the upstream and downstream extremities of Maddox Bay. Mussel bed formation seemed limited by excessive fine sediment build up in the lentic habitats that extended from toe of bank slope to toe of bank slope across the channel width and sometimes extending up the slope for several meters. Even though mussel bed formation was limited in the lentic habitats, there were still concentrations of mussels present nearshore, but usually in a narrow band (0.5 – 1.0 meter) in relatively shallow water (0.5 – 1.5 meters). Lentic habitat is defined as occurring between Map Sites 29 – 42, a stream distance of approximately 3.55 stream km (2.2 stream miles). Lotic habitat occurred between Map Sites 1 – 28 (downstream end) and between Maps Sites 43 – 73 (upstream end). Mussel bed formation in lotic habitats was limited by excessive large woody debris usually due to bank failure and tree fall. Upstream of tree falls, sediment deposition usually occurred creating smothering substrates unsuitable for high mussel density to occur. Downstream of tree falls, smothering substrates might occur if current velocity was substantially blocked or if high velocity flow was able to go over or under the tree fall, substrate scouring occurred which also limited high densities of mussels.

Indian Bayou – was observed to be the smallest of the four streams sampled in terms of stream width and stream depth. Many sample sites were wadable (<1.0 m deep) and did not require dive sampling, and stream width was often <25 m (~ 80 feet) wide which was seldom the case with the other three streams sampled. Noticeable current velocity was present throughout most of Indian Bayou, and riffle or run habitat with sand or sand/gravel substrate was more prevalent in Indian Bayou than in the other three streams. The dominant mussel species (% total) in Indian Bayou were more evenly distributed that the other three streams with five species comprising >10% of total mussels (Table 11). Habitat was poor at the upstream end where Indian Bayou diverged from Maddox Bay with sharp bendways that were scoured and had substantial bank failure. Approximately 1.4 stream km (0.9 stream mi) downstream of the divergence, habitat improved and mussel density increased throughout Indian Bayou down to AR Hwy 1. Downstream of AR Hwy 1, increased current velocity appeared to have caused bank failure in bendways and introduced a substantial amount of large woody debris into Indian Bayou which created relatively poor mussel habitat.

Big Island Chute – was observed to be substantially modified for the upstream most 2.4 stream km (1.5 stream mi) due to swift current velocity from the White River causing bank failure, large woody debris blockages, and excessive sand deposition which created relatively poor mussel habitat. Mussel beds were most often associated with gentle bendways, although large woody debris from treefalls or bank sloughing were often present and interrupted bed continuity. Downstream of Refuge Road bridge, there is evidence of a large bank failure that is in progress along the right descending bank for a distance of >1.0 stream km (0.6 stream mi) with large trees and intact bank sloughed into the channel (Figure 10). The downstream most 2.2 stream km (~1.4 stream mi) of Big Island Chute may be affected by periodic backwater from White River as there was increased fine grained sediment (silt with pudding-like consistency and sand) from bank to bank which created relatively poor mussel habitat. Big Island Chute was the most similar to White River of the four tributaries sampled as evidenced by presence of 16 specimens at 15 sites of the large river obligate species *Obovaria olivaria* (Haag 2012). Only 1 other specimen was found among the three other streams.

LaGrue Bayou – mussel beds were observed in the gentle bendways (Figure 11) that provided current that kept substrate swept clean of excessive fine sediments; however, this specific habitat was not common. More common were sharp, looping bendways such as between Map Sites 2-8 and 17-31 that caused substrate scour and bank failure introducing excessive large woody debris to the stream.

Overall Mussel Community - Mussel assemblages show predictable structure in which dominance is shared by a small group of co-dominants species, and a larger group of subordinate species occur at lower abundance. Typically, 3-5 species make up 60-75 percent of individuals (Haag 2012). Large rivers in the Mississippian region are consistently dominated by a small group of species including large river specialists like *Reginaia ebenus*, and stream size generalists such as *Amblema plicata* and *Cyclonaias pustulosa*. *Plectomerus dombeyanus* and *Quadrula quadrula* can also be among the dominant species in some large rivers (Haag 2012). These relationships hold true for the qualitative sampling in this study. Table 10 shows those species that contributed >10% of total specimens for the streams sampled in this survey and for

White River in previous surveys. *Quadrula quadrula* was dominant in three of four tributary streams (22.0 - 40.5%) and White River, and either *Amblema plicata* (Maddox Bay, LaGrue Bayou) or *Cyclonaias pustulosa* (Indian Bayou, Big Island Chute) the second most dominant species.

A considerable amount of effort has been expended to locate and define mussel beds in the White River and its tributary, the Cache River. Christian (1995) located and defined 10 major mussel beds (≥500 m² area, ≥10 mussels/m² density) and 11 minor beds (<500 m² area, ≥10 mussels/m² density) in the White River from the confluence of the Cache River downstream to the confluence with the Arkansas River, a distance of approximately 143.2 river km (89 river mi). The dominant species of Maddox Bay, Big Island Chute, and LaGrue Bayou were most similar to White River mussel beds within the NWR. Indian Bayou was substantially different from the three other study streams in both its physical habitat and dominant species composition (*Fusconaia flava*, *Eurynia dilatata*) that reflect its closer similarity to mid-sized streams rather than large streams. The uniqueness of the Indian Bayou fish fauna and similarity to both medium and large-size streams have been noted by Buchanan (1998).

Of some interest, *Leptodea fragilis*, a species that is characterized as opportunistic and somewhat tolerant of impoundment, is the second most abundant species in the two downstream most mussel beds in the White River (RM 29.8 = 29.7%, RM 18.5 = 38.9%) and the dominant species in the somewhat artificial mussel bed at Clarendon (RM 99 = 37.0%) that is established in bank stabilization rip rap along the left descending bank. Opportunistic species are characterized as having short life spans, early maturity, and high fecundity, and also have the fastest growth rates and highest reproductive effort of any North American species (Haag 2012). These characteristics are considered adaptations for rapid colonization and persistence in disturbed and unstable but productive habitats (Haag 2012). *Leptodea fragilis* was a relatively minor component (0.3% - 2.8%) of the mussel fauna in the four tributary streams of the present study.

A total of 35 mussel beds were located and defined during this study. While the majority were medium sized (n = 27) and comparable to mussel beds found in the main channel White River, one mussel bed in Maddox Bay was classified as large encompassing an estimated 16,500 m^2, larger than any mussel bed found in the White River. If quantitative sampling is conducted in the future, additional more detailed effort should be expended to define mussel bed limits and area prior to sampling.

<u>Conservation Status and Arkansas SGCN</u> – 29 native freshwater mussel species have been documented to occur in the White River mainstem within the NWR along with the invasive bivalve species *Corbicula fluminea* and *Dreissena polymorpha* (see Table 1). There were 31 native mussels plus the invasive *Corbicula fluminea* encountered in the four tributary streams sampled during this survey (see Table 1). Most freshwater mussels found in main channel White River plus sampled tributaries are relatively common species with broad geographic distributions, and 26 of 35 native species (~74%) are considered apparently secure (S4) or secure (S5) in Arkansas (Harris and Posey 2015). Six species currently known from the main channel White River and sampled tributaries are considered vulnerable (S3), i.e. at moderate risk of extirpation due to restricted range or relatively few populations or occurrences. Three species

are considered imperiled (S2) - at high risk of extirpation in Arkansas due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.

Seven species currently considered species of greatest conservation need in Arkansas were found in the four tributary streams. Two species, *Quadrula apiculata* and *Q. nobilis* were found in relatively large numbers and at a large number of sample sites. These species have only recently been recognized as occurring in Arkansas (Harris *et al*. 2010), and they are difficult to identify using morphological characters. Historically, these have been grouped under *Quadrula quadrula*, and phylogenetic studies are underway at several facilities to develop more reliable morphological characteristics to correctly identify these species. Voucher specimens from this study are being provided for genetic analyses to confirm their correct identifications.

Obovaria arkansasensis is not currently considered an Arkansas SGCN; however, relatively recent genetic studies have determined there is an undescribed *Obovaria* species in the Little Red River of the White River drainage (Inoue *et al*. 2013). The discovery of large numbers of specimens tentatively identified as *Obovaria jacksoniana* in Maddox Bay and smaller numbers in Indian Bayou and LaGrue Bayou was unexpected, as there were no previous records from the White River drainage south of Clarendon. Voucher specimens were collected and tissue samples have been sent for genetic analysis to determine if these populations are more closely related to the widespread *Obovaria arkansasensis* or to *Obovaria sp*. known only from the Little Red River, AR. If more closely related to *Obovaria sp*., these populations from the White River tributaries in the refuge are likely to be designated as Arkansas SGCN in the future, as Harris and Posey (2015) considered *Obovaria sp*. as S2 or imperiled in Arkansas.

Uniomerus declivis was found only as a single relict specimen in Indian Bayou. It is often found in overflow channels or permanently flooded wetlands adjacent to larger streams. Numerous specimens have been found in these habitats within the St. Francis River and Bayou Bartholomew drainages (Harris *et al*. 2010). It is likely that this species is more common in smaller tributary streams within the White River NWR.

Of the four native species that have been found only in the main channel White River, it would not be surprising with additional search effort to find three of those species occur in the tributaries sampled during this study. Specifically, the endangered *Potamilus capax* has been found in the White River in silt substrate of an inside bendway in habitat sheltered from strong current velocity. This specific habitat is common, especially in the downstream portions of Big Island Chute and LaGrue Bayou, and to a lesser extent in middle portions of Maddox Bay. The threatened *Theliderma cylindrica* has been found in the White River in habitat ranging from rip rap protected bank slopes near Clarendon to 9+ m (30+ foot) deep water in the mussel bed at Aberdeen (RM 91), so it is able to inhabit somewhat variable habitats. *Theliderma cylindrica* could eventually be found in any of the four streams sampled during this study. *Theliderma metanevra* inhabits medium to large rivers and has been found in four mussel beds within the NWR. *Theliderma metanevra* seems partial to moderate to swift current with hard substrates (rock, gravel, gravel/sand) similar to some reaches in Indian Bayou, Big Island Chute, and LaGrue Bayou. *Dreissena polymorpha*, the invasive Zebra Mussel, has only been found in the main channel White River and not the tributaries. It is thought to be primarily a large river species, and it has found in the Clarendon vicinity (Harris and Christian 2000). Although the Zebra Mussel could eventually invade the tributaries, that occurrence is not considered likely.

Management Considerations and Monitoring Recommendations

Protection or improvements in the status of mussels in the four Dale Bumpers White River NWR streams surveyed requires proper management of the watersheds and cooperative efforts of stakeholders. The following management and monitoring recommendations are provided to assist with future refuge management.

1. Collection of baseline sediment composition in mussel beds defined during this study followed by periodic monitoring of sediment composition may provide insights into whether influxes of fine sediment loading in these streams are affecting the mussel community.

2. Implementation of best management practices to reduce sediment runoff from road maintenance, forestry activities, and agricultural practices should serve to improve water quality and habitat availability in the study streams. Execution of BMPs should improve and/or sustain the quality and quantity of vegetative cover in riparian areas, decrease siltation, and subsequently improve habitat quality for mussels.

3. Proper management of native mussel resources includes periodic monitoring. Implementation of a "mussel monitoring program" should be considered for Dale Bumpers White River NWR to establish and track population size, demography, recruitment, and status of the freshwater mussel community. Selected mussel beds should be quantitatively assessed and monitored at a 10-year interval.

4. U.S. Army Corps of Engineers operation and management of Lock and Dam systems in the upper reaches of the White River drainage may have altered species richness and abundance in the Dale Bumpers White River NWR study area. Efforts focused on analysis and operational implementation of statistically optimized designer flow regimes (Poff and Olden 2017, Sabo *et al*. 2017) to restore habitats and more natural flow regimes may result in increases of species richness within the refuge.

ACKNOWLEDGMENTS

I want to thank Jay Hitchcock and Mark Tapp, U. S. Fish and Wildlife Service, for their efforts in developing, acquiring funding, and guiding this project to completion. David Richardson and Jay Hitchcock carefully reviewed the draft report and provided valuable comments and insights that greatly improved the final product. Billy Justus and Robert Hudson were instrumental in acquiring and providing access to survey Maddox Bay. Eddie Simmons provided valuable historical information regarding commercial mussel bed locations and access to survey streams. Thanks to Aaron Harris for preparing the figures and enduring the ridiculous number of revisions and edits. Josh Seagraves was an invaluable asset in all aspects of sampling and defining mussel beds during this study, and the survey could not have been accomplished without his efforts.

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FIGURES

Figure 1. Project area illustrating locations of Maddox Bay (🟠), Indian Bayou (🟡), Big Island Chute (🔴), and LaGrue Bayou (🔵).

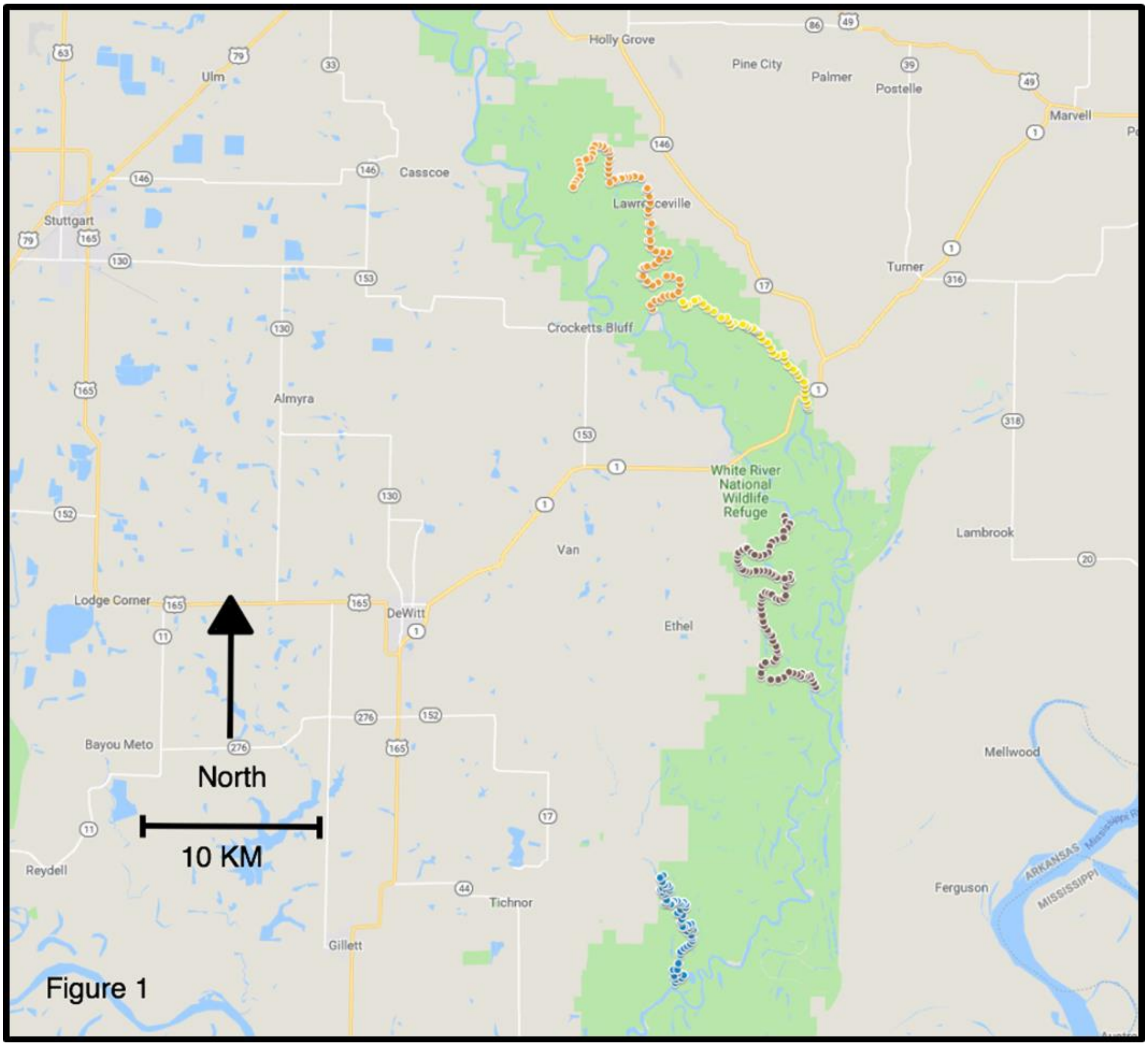

Figure 2. Maddox Bay mussel sample sites within Dale Bumpers White River National Wildlife Refuge.

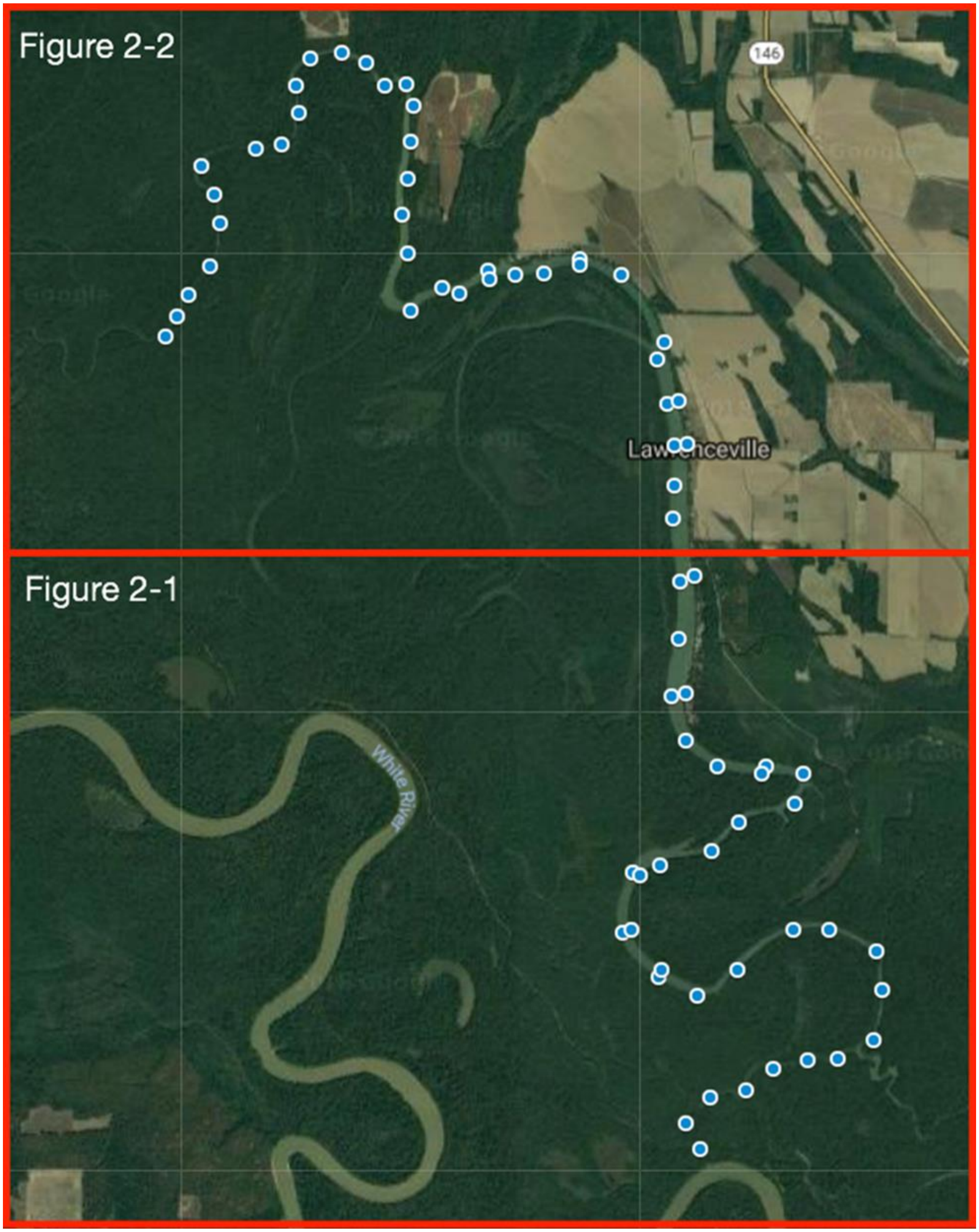

Figure 2-1. Maddox Bay sample sites 1–34 within Dale Bumpers White River National Wildlife Refuge.

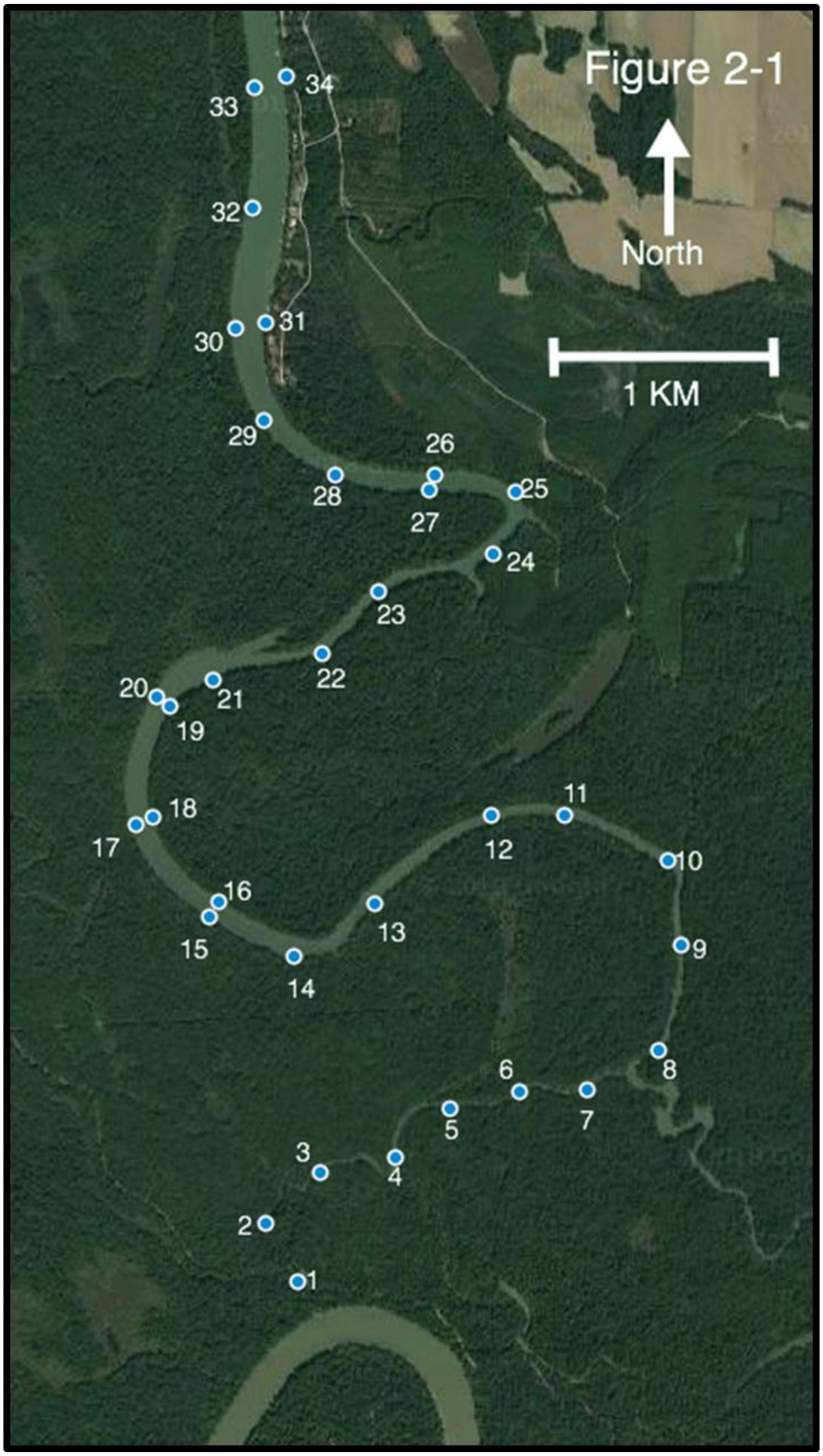

Figure 2-2. Maddox Bay sample sites 35–73 within Dale Bumpers White River National Wildlife Refuge.

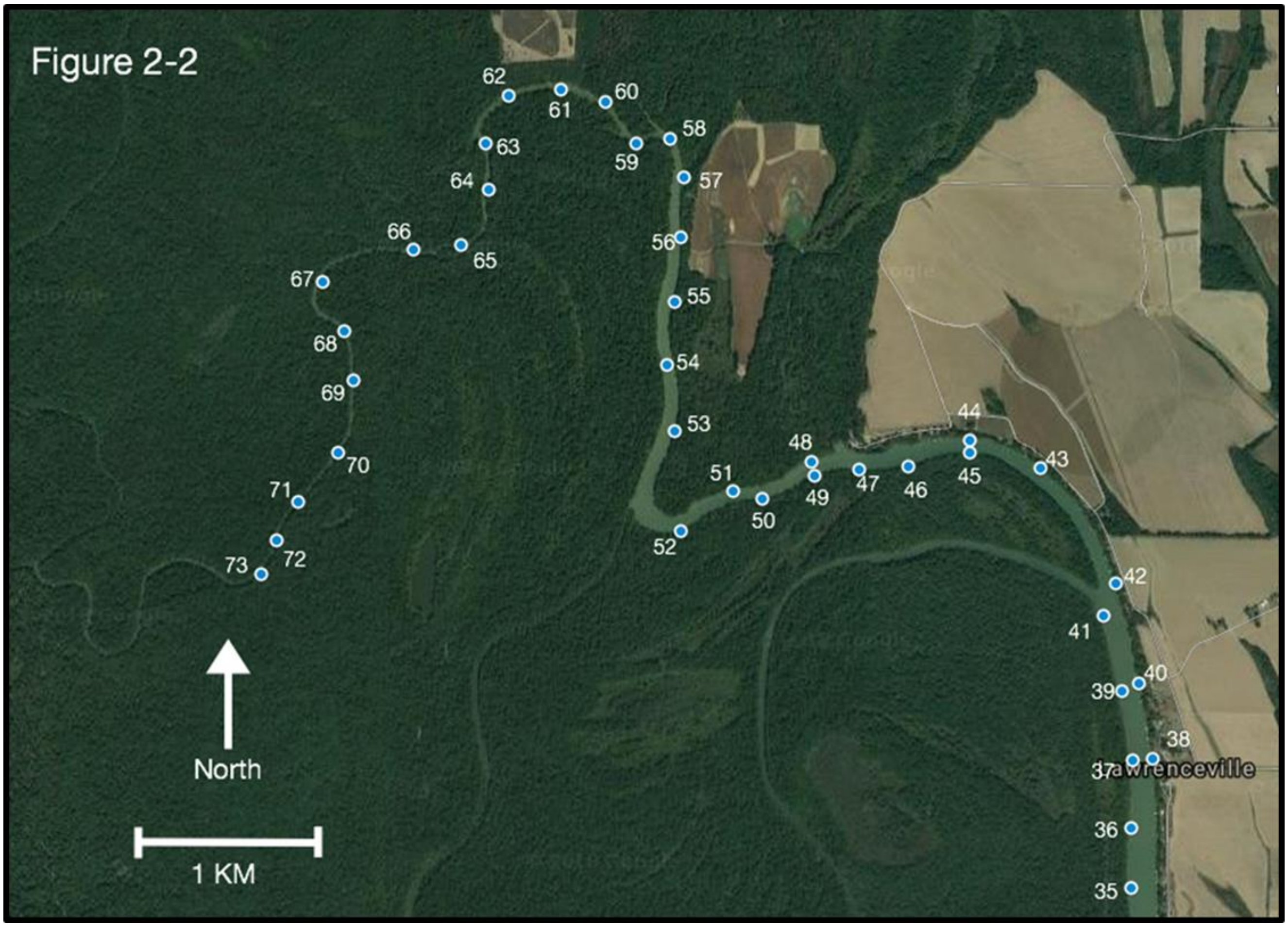

Figure 3. Maddox Bay mussel bed locations within Dale Bumpers White River National Wildlife Refuge.

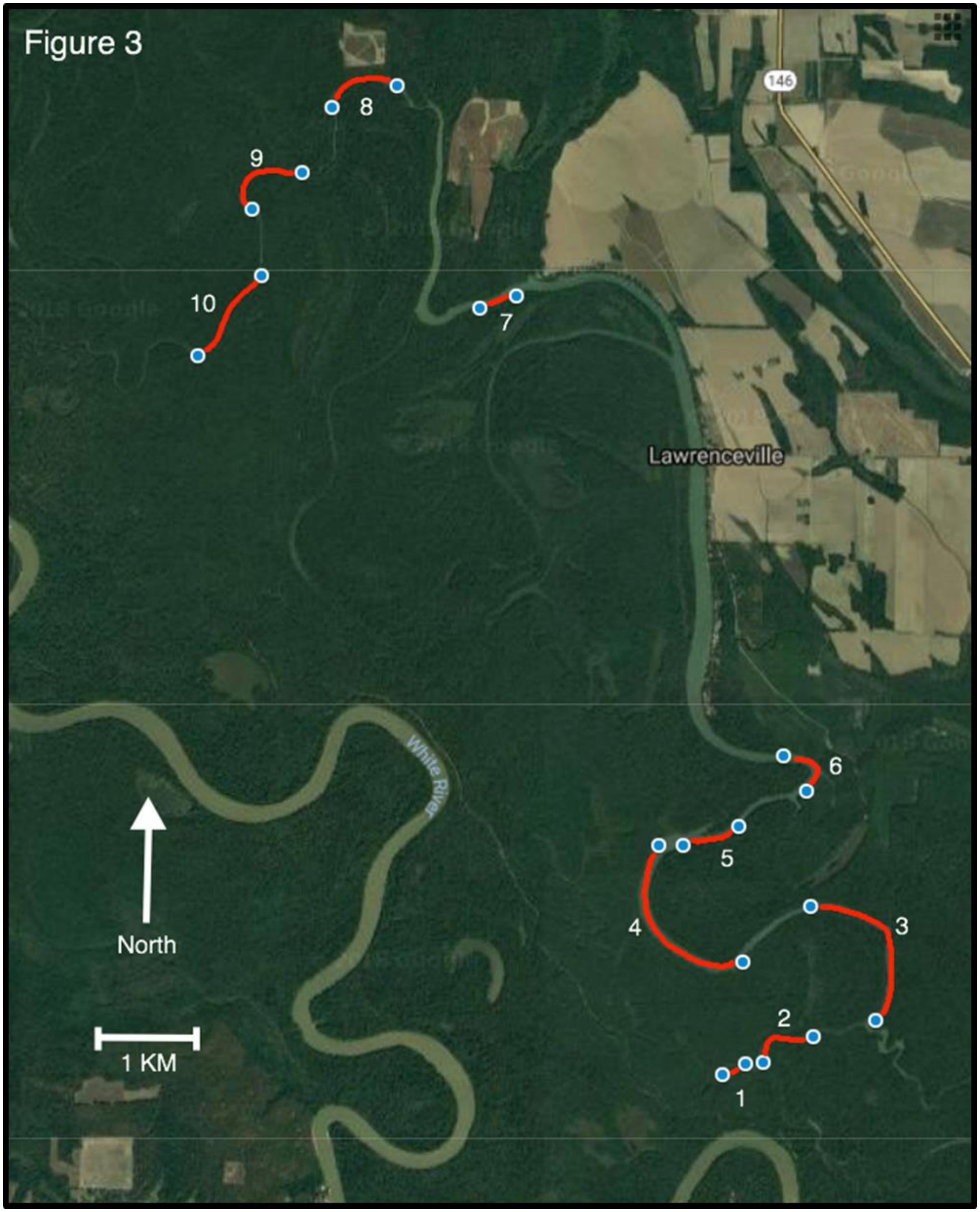

Figure 4. Indian Bayou mussel sample sites within Dale Bumpers White River National Wildlife Refuge.

Figure 5. Indian Bayou mussel bed locations within Dale Bumpers White River National Wildlife Refuge.

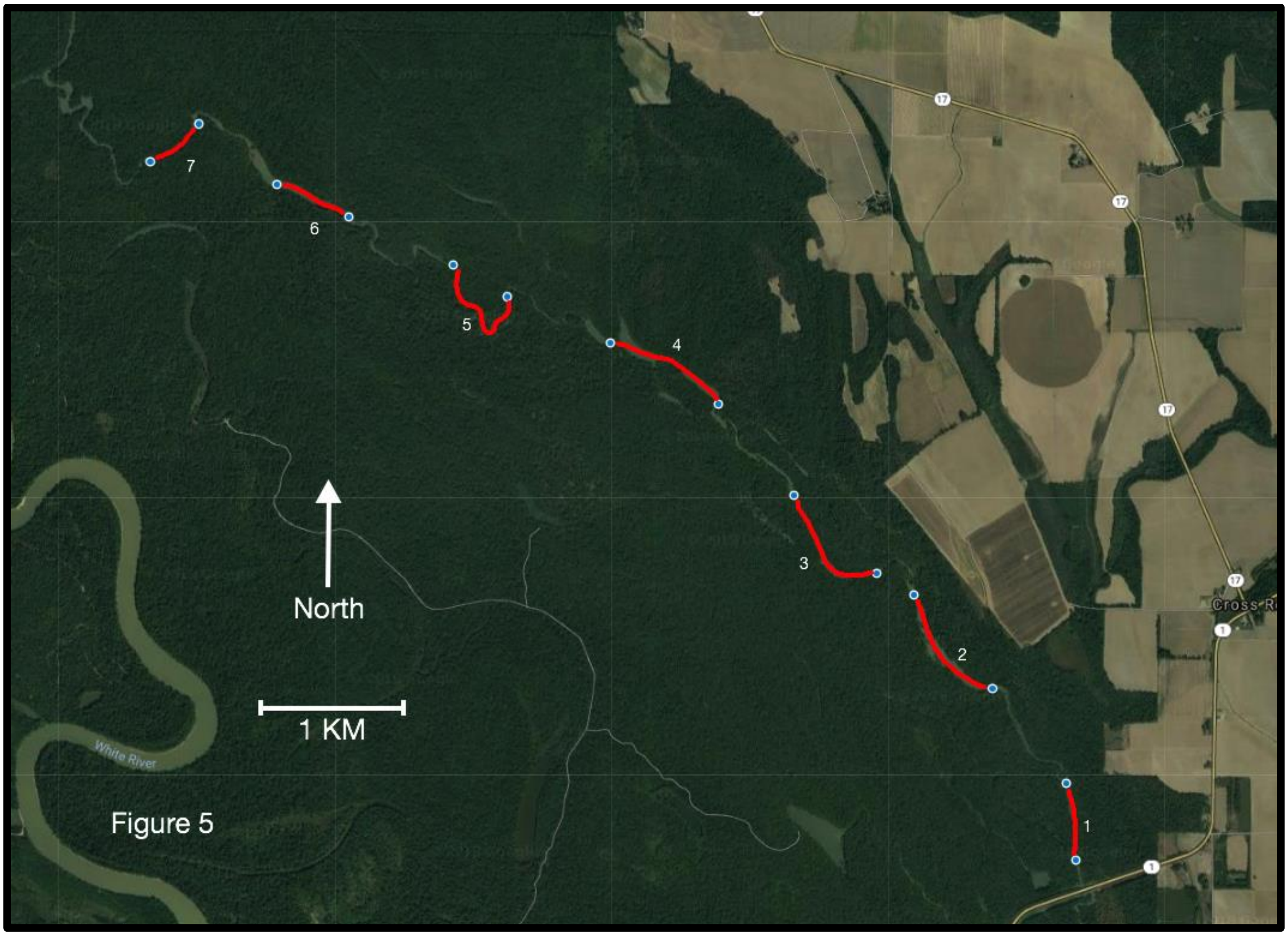

Figure 6. Big Island Chute mussel sample sites within Dale Bumpers White River National Wildlife Refuge.

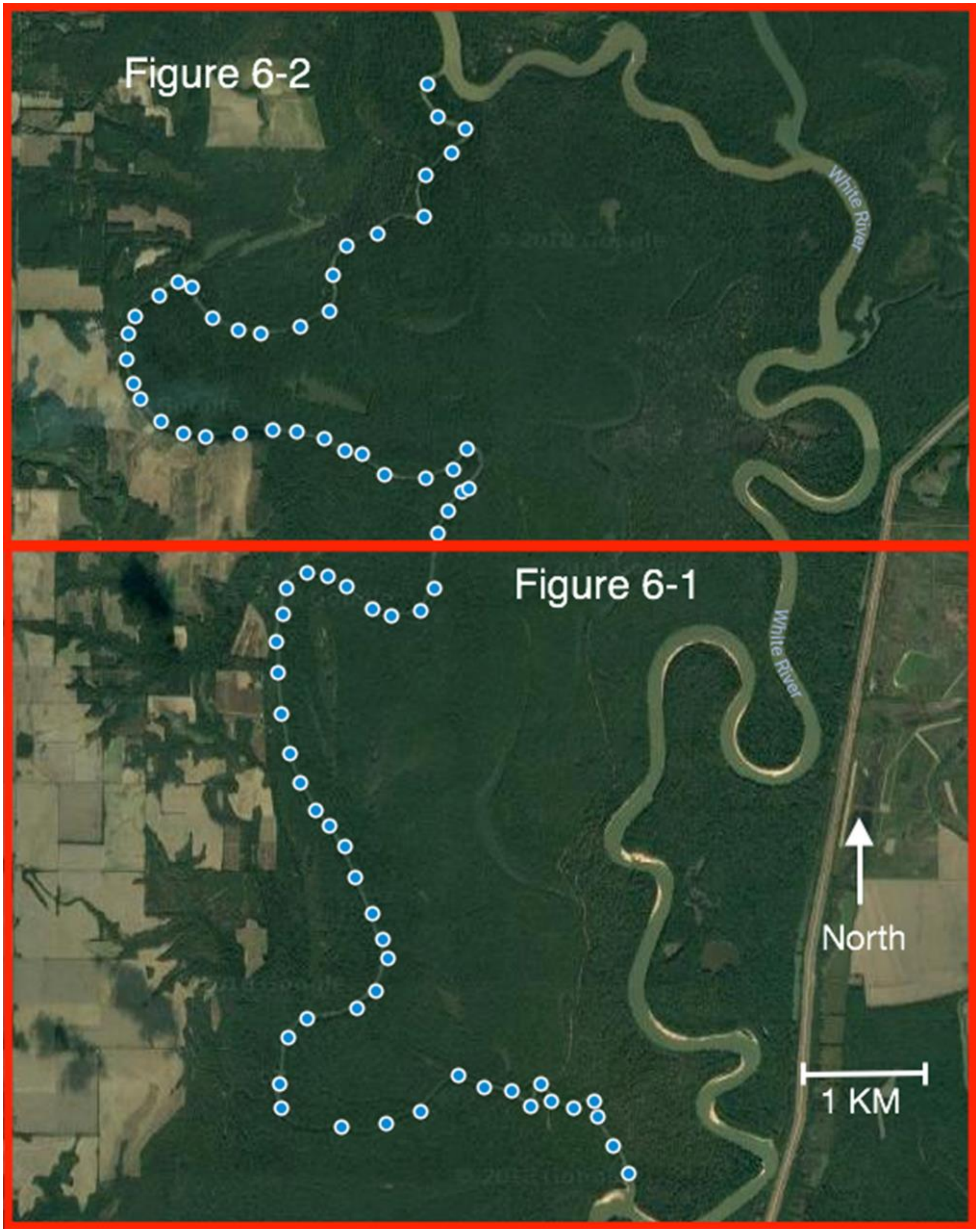

Figure 6-1. Big Island Chute mussel sample sites 1–41 within Dale Bumpers White River National Wildlife Refuge.

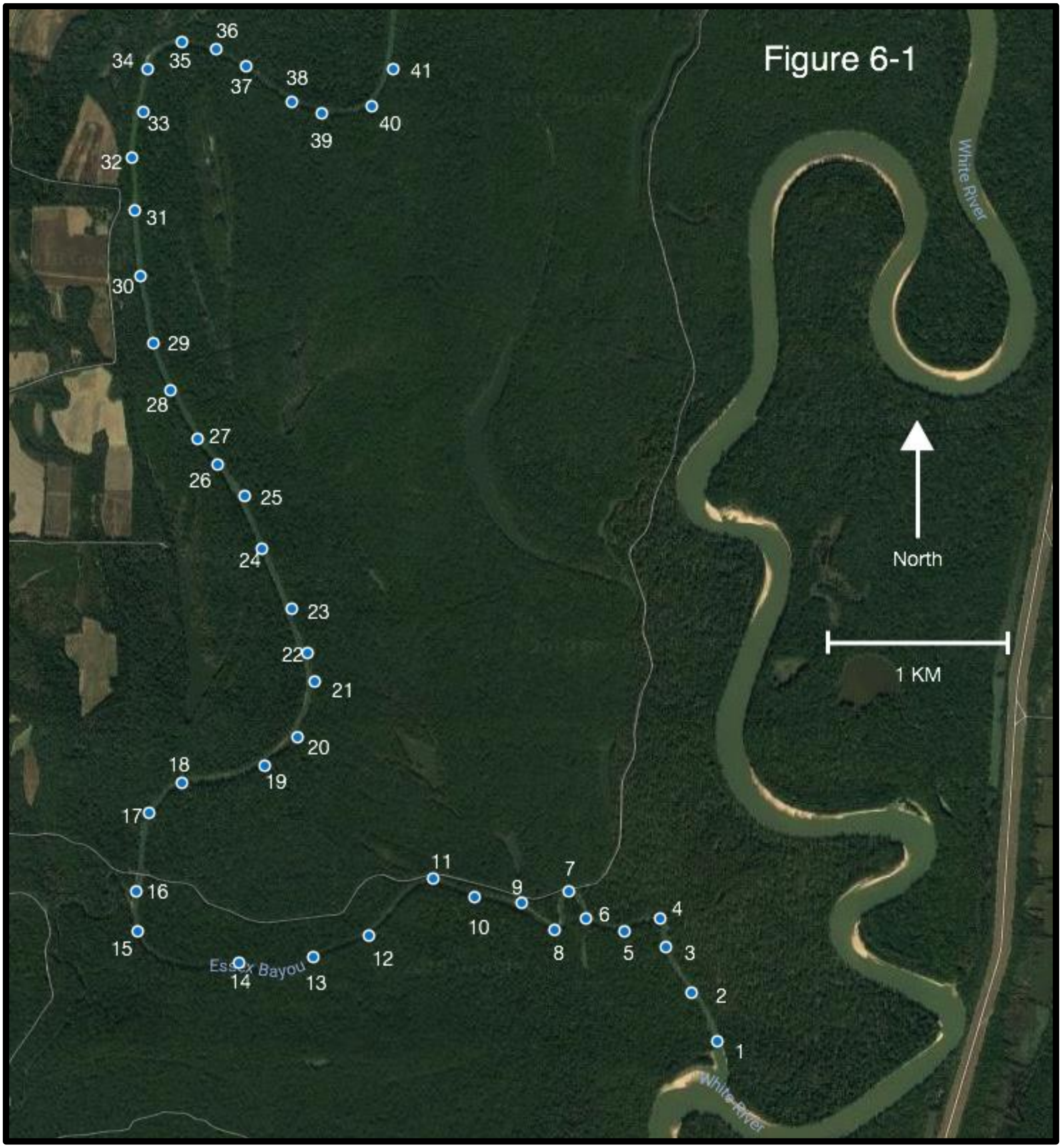

Figure 6-2. Big Island Chute mussel sample sites 42–80 within Dale Bumpers White River National Wildlife Refuge.

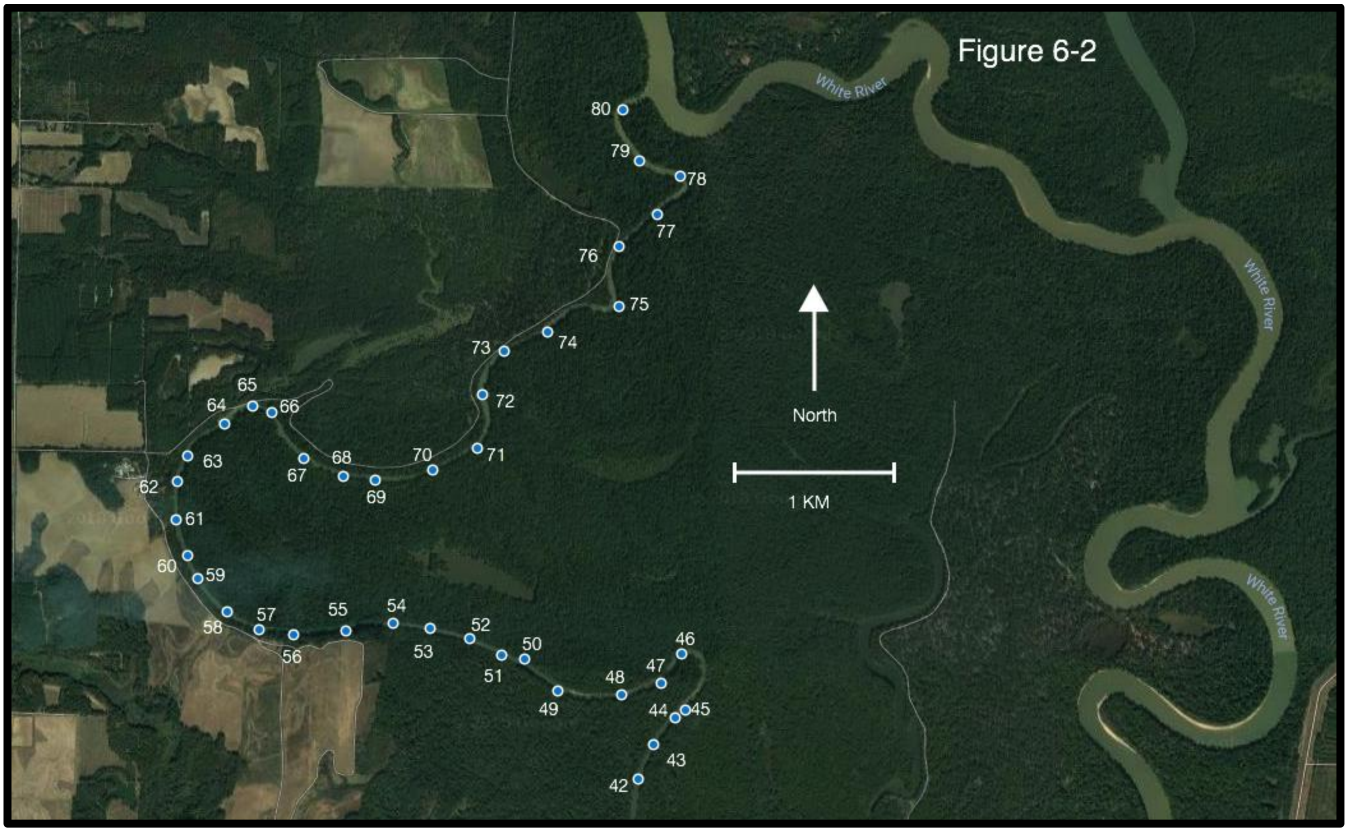

Figure 7. Big Island Chute mussel bed locations within Dale Bumpers White River National Wildlife Refuge.

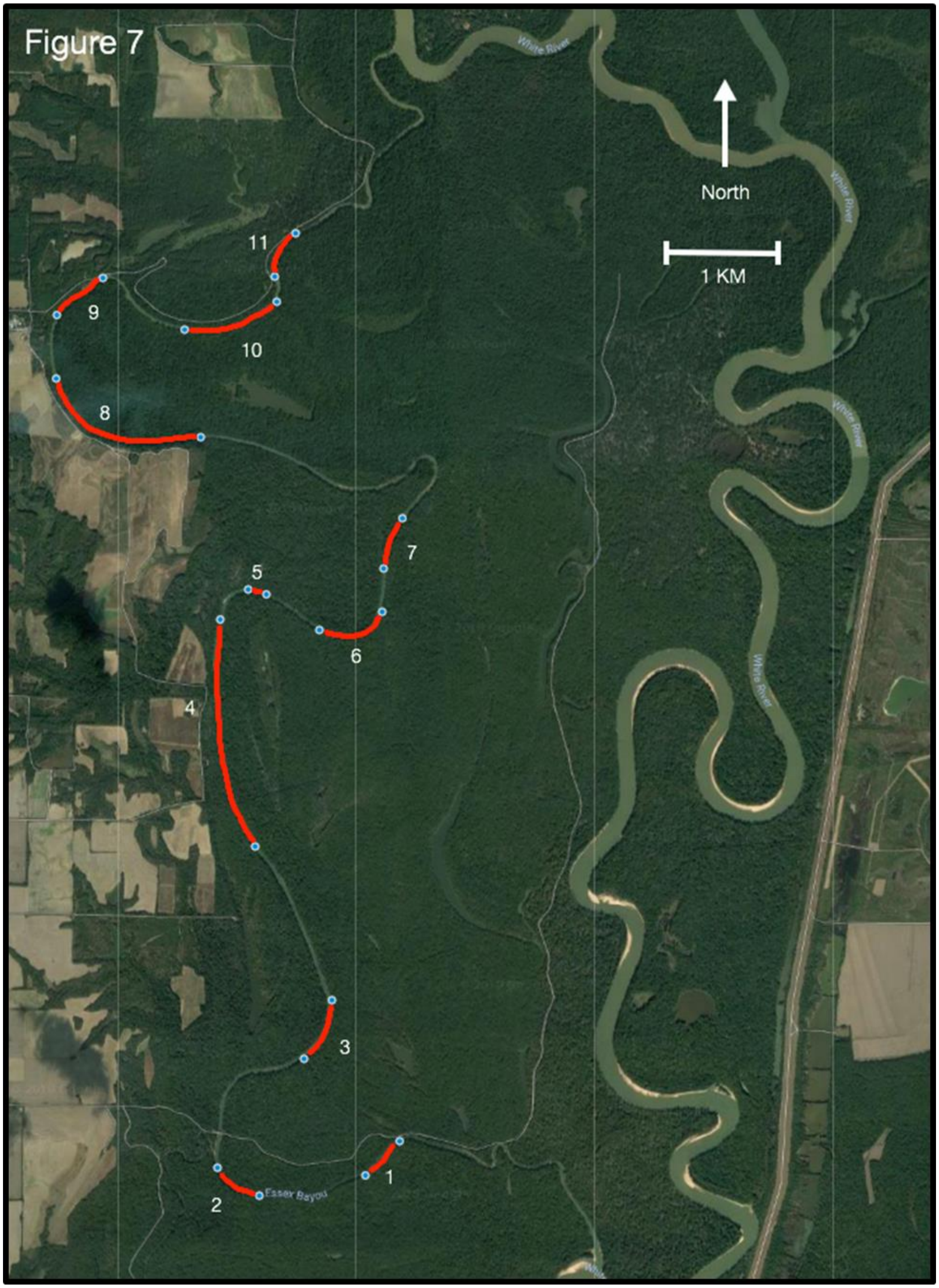

Figure 8. LaGrue Bayou mussel sample sites within Dale Bumpers White River National Wildlife Refuge.

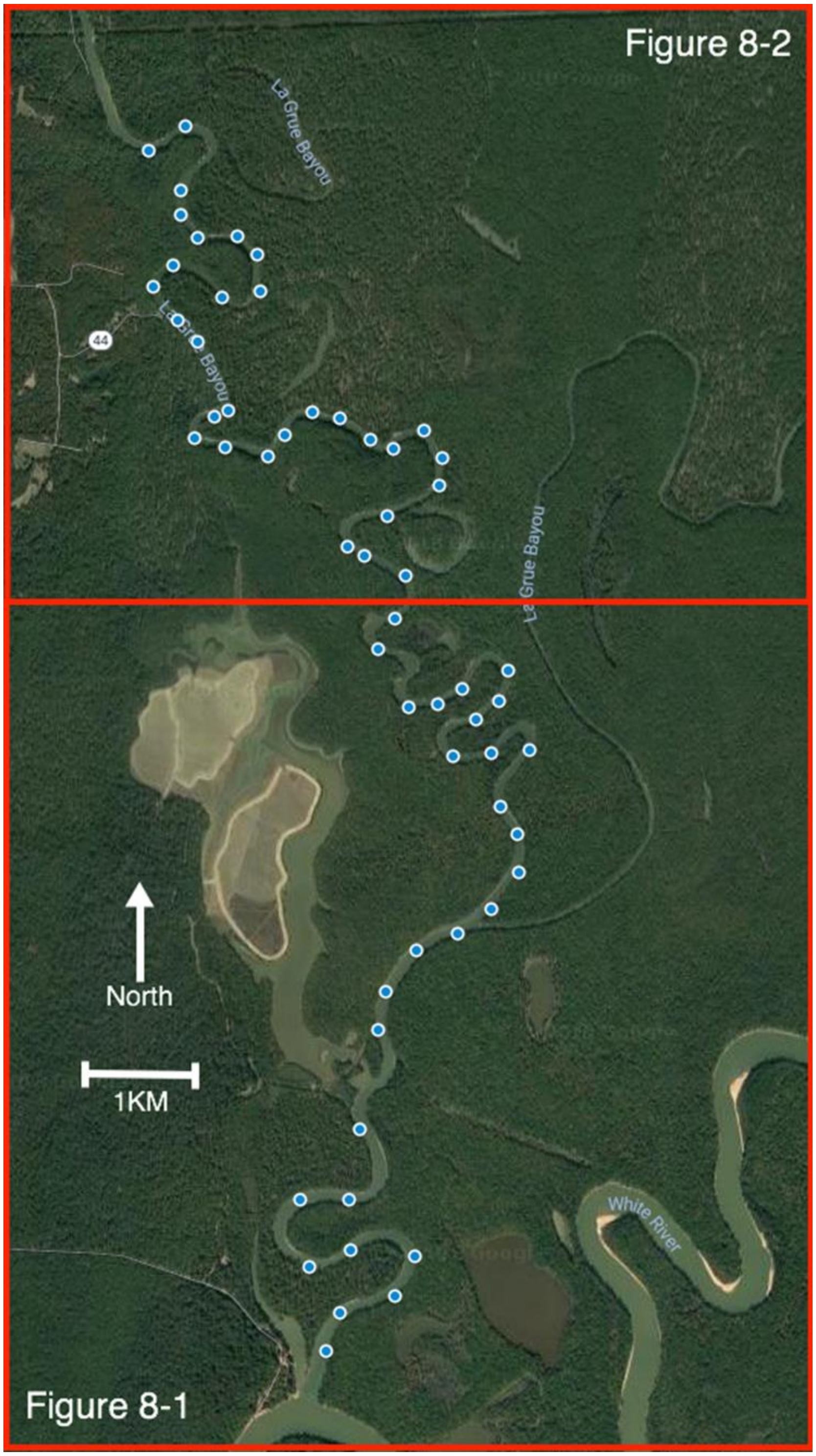

Figure 8-1. LaGrue Bayou mussel sample sites 1–28 within Dale Bumpers White River National Wildlife Refuge.

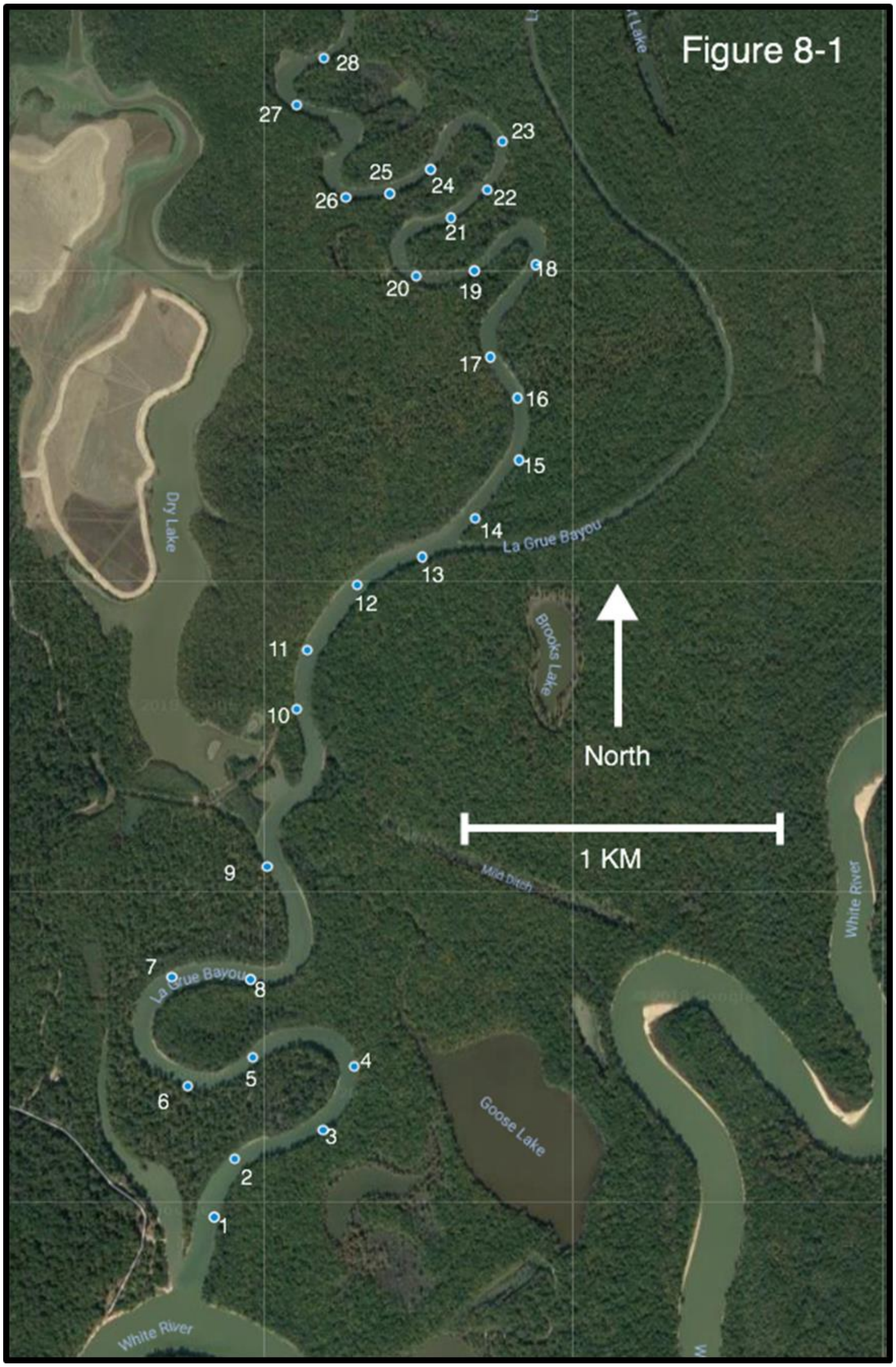

Figure 8-2. LaGrue Bayou mussel sample sites 29–58 within Dale Bumpers White River National Wildlife Refuge.

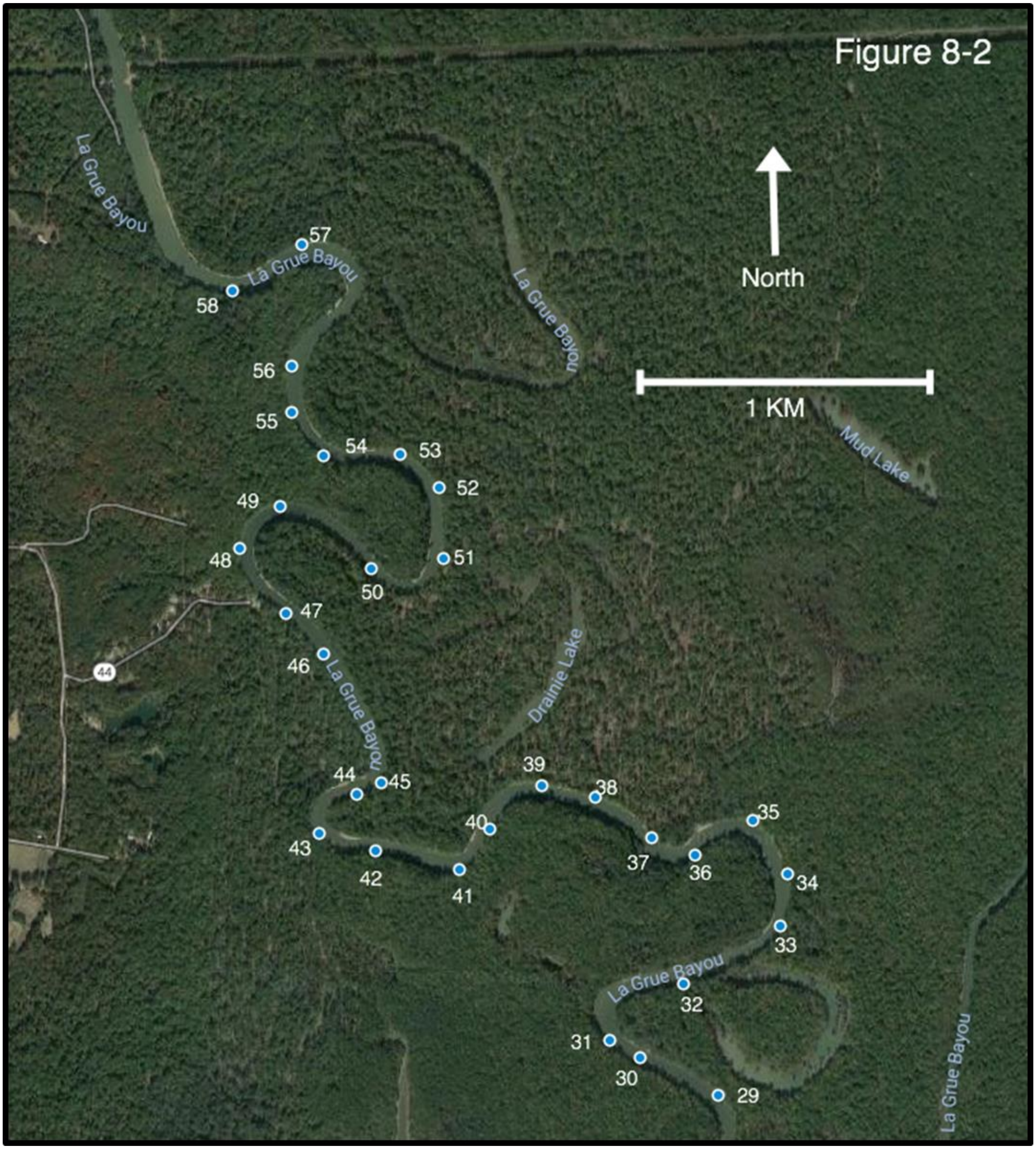

Figure 9. LaGrue Bayou mussel bed locations within Dale Bumpers White River National Wildlife Refuge.

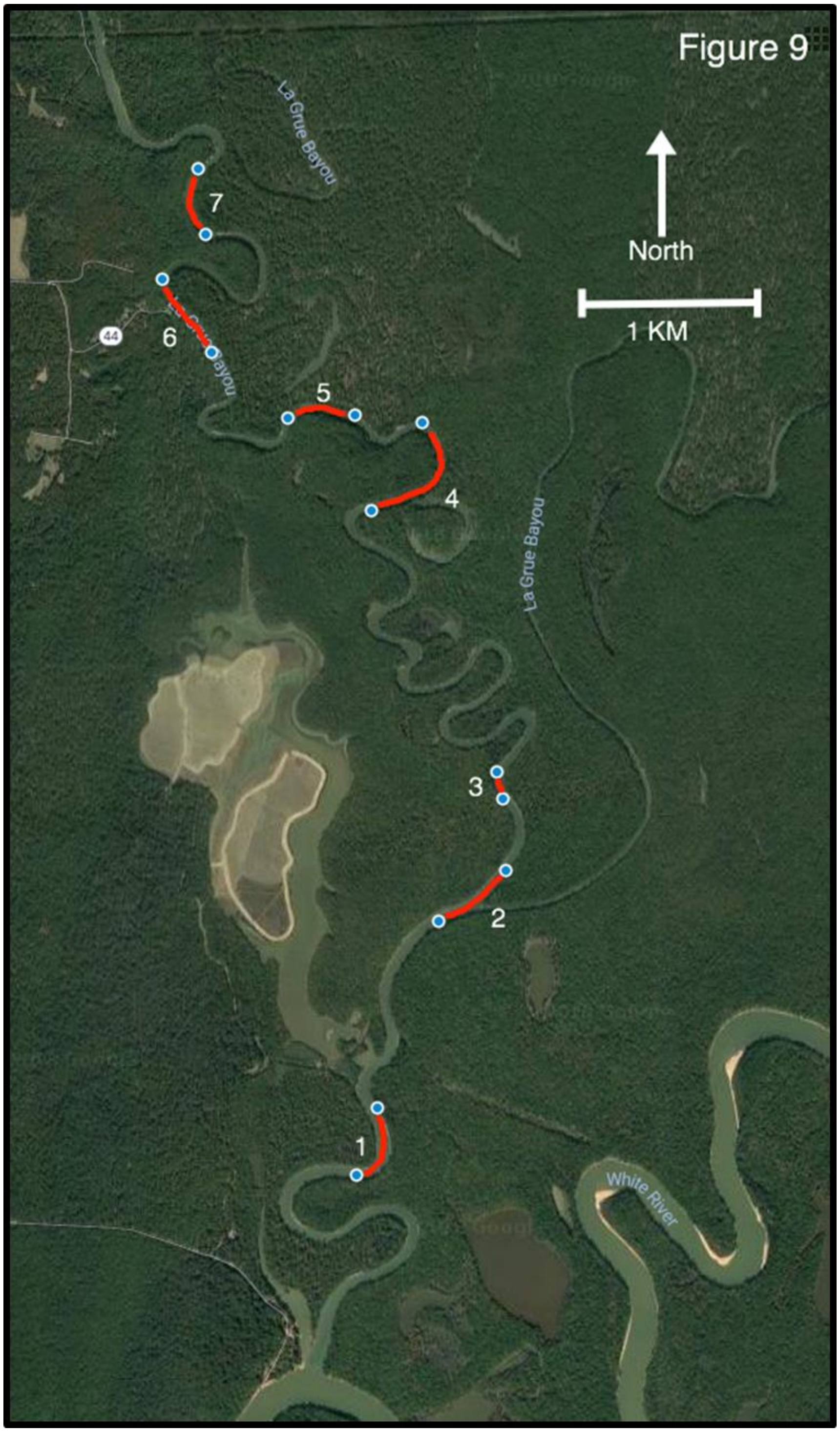

Figure 10. Maddox Bay Map Site 4 showing upstream (top) and downstream (bottom) views of mussel bed habitat with visible flow and stream width 23 meters (75 feet).

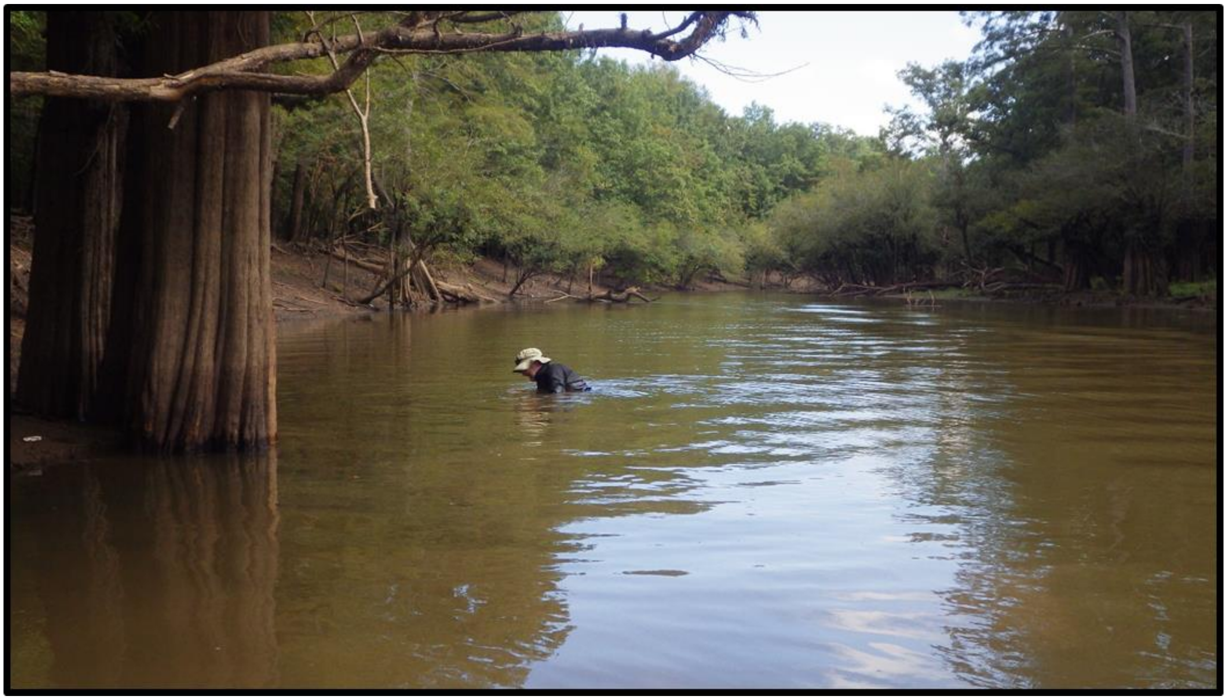

Photo by Josh H. Seagraves

Photo by Josh H. Seagraves

Figure 11. Maddox Bay Map Site 31 upstream (top) and downstream (bottom) views showing lentic habitat with no visible flow and channel width 151 meters (495 feet).

Photo by John L. Harris

Photo by John L. Harris

Figure 12. Bank failure along right descending bank of Big Island Chute downstream of Refuge Road bridge. Note tree standing in channel.

Photo by John L. Harris

Figure 13. Upstream view from LaGrue Bayou Bed 5 at Map Site 39 illustrating gentle bendway along left descending bank.

Photo by John L. Harris

Table 1. Scientific and common names used in this report. Names follow Williams *et. al*. (2017). White River occurrences are from Christian (1995), Harris and Chordas (2000), Harris and Christian (2000, 2003). *Indicates invasive species.

Scientific Name - Williams *et al*. 2017	Common Name	White River	Tributaries
Amblema plicata (Say 1817)	Threeridge	X	X
Arcidens confragosus (Say 1829)	Rock Pocketbook	X	X
Cyclonaias nodulata (Rafinesque 1820)	Wartyback	X	X
Cyclonaias pustulosa (Lea 1831)	Pimpleback	X	X
Ellipsaria lineolata (Rafinesque 1820)	Butterfly	X	X
Eurynia dilatata Rafinesque 1820	Spike	X	X
Fusconaia flava (Rafinesque 1820)	Wabash Pigtoe	X	X
Lampsilis abrupta (Say 1831)	Pink Mucket	X	
Lampsilis cardium Rafinesque 1820	Plain Pocketbook	X	X
Lampsilis hydiana (Lea 1838)	Louisiana Fatmucket		X
Lampsilis teres (Rafinesque 1820)	Yellow Sandshell	X	X
Lasmigona complanata (Barnes 1823)	White Heelsplitter	X	X
Leptodea fragilis (Rafinesque 1820)	Fragile Papershell	X	X
Megalonaias nervosa (Rafinesque 1820)	Washboard	X	X
Obliquaria reflexa Rafinesque 1820	Threehorn Wartyback	X	X
Obovaria arkansasensis (Lea 1862)	Southern Hickorynut		X
Obovaria olivaria (Rafinesque 1820)	Hickorynut	X	X
Plectomerus dombeyanus (Valenciennes 1827)	Bankclimber	X	X
Potamilus capax (Green 1832)	Fat Pocketbook	X	
Potamilus ohiensis (Rafinesque 1820)	Pink Papershell	X	X
Potamilus purpuratus (Lamarck 1819)	Bleufer	X	X
Pyganodon grandis (Say 1829)	Giant Floater	X	X
Quadrula apiculata (Say 1829)	Southern Mapleleaf	X	X
Quadrula nobilis (Conrad 1854)	Gulf Mapleleaf	X	X
Quadrula quadrula (Rafinesque, 1820)	Mapleleaf	X	X
Reginaia ebenus (Lea 1831)	Ebonyshell	X	X
Theliderma cylindrica (Say 1817)	Rabbitsfoot	X	
Theliderma metanevra (Rafinesque 1820)	Monkeyface	X	
Toxolasma texasiense (Lea 1857)	Texas Lilliput		X
Tritogonia verrucosa (Rafinesque 1820)	Pistolgrip	X	X
Truncilla donaciformis (Lea 1828)	Fawnsfoot	X	X
Truncilla truncata Rafinesque 1820	Deertoe	X	X
Uniomerus declivis (Say 1831)	Tapered Pondhorn		X
Utterbackia imbecillis (Say, 1829)	Paper Pondshell		X
Villosa lienosa (Conrad 1834)	Little Spectaclecase		X
Corbicula fluminea (Mueller 1774)*	Asian Clam*	X	X
Dreissena polymorpha (Pallas 1771)*	Zebra Mussel*	X	

Table 2. Summary of mussels collected during survey of Maddox Bay. FREQ = number of sample sites where species occurred live. AR Conservation Status Rank follows Harris and Posey (2015). Total sites = 73.

Species	TOTAL	% TOTAL	Occurrence	% Occurrence	AR Conservation Status Rank
Amblema plicata	596	19.3	66	90.4	S5
Arcidens confragosus	56	1.8	32	43.8	S4
Cyclonaias nodulata	103	3.3	36	49.3	S4
Cyclonaias pustulosa	199	6.4	35	47.9	S5
Eurynia dilatata	36	1.2	11	15.1	S5
Fusconaia flava	454	14.7	52	71.2	S5
Lampsilis cardium	7	0.2	7	9.6	S5
Lampsilis hydiana	10	0.3	9	12.3	S4
Lampsilis teres	33	1.1	24	32.9	S5
Lasmigona complanata	2	0.1	2	2.7	S4
Leptodea fragilis	9	0.3	8	11	S5
Megalonaias nervosa	60	1.9	35	47.9	S4
Obliquaria reflexa	137	4.4	42	57.5	S5
Obovaria arkansasensis	231	7.5	38	52.1	S4
Obovaria olivaria	1	<0.1	1	1.4	S3
Plectomerus dombeyanus	235	7.6	59	80.8	S4
Potamilus ohiensis	1	<0.1	1	1.4	S4
Potamilus purpuratus	5	0.2	4	5.5	S5
Pyganodon grandis	26	0.8	20	27.4	S5
Quadrula apiculata	48	1.6	27	37	S3
Quadrula nobilis	41	1.3	23	31.5	S3
Quadrula quadrula	679	22.0	68	93.2	S4
Reginaia ebenus	3	0.1	3	4.1	S5
Toxolasma texasiense	13	0.4	10	13.7	S3
Tritogonia verrucosa	33	1.1	19	2.6	S5
Truncilla donaciformis	3	0.1	3	4.1	S3
Truncilla truncata	64	2.1	33	45.2	S4
Utterbackia imbecillis	3	0.1	3	4.1	S4
TOTAL	3088	100	73	100	

Table 3. Maddox Bay reaches with estimated mussel densities ≥ 10/m² defined as mussel beds.

Bed Number	Bed Location (Map Numbers)	Estimated Length	Estimated Mean Width	Bed Area	Bed Size
1	03	250 m	3 m	750 m^2	small
2	04 - 05	650 m	3 m	1,950 m^2	medium
3	08 - 12	1,650 m	10 m	16,500 m^2	large
4	13-15, 17, 19	1,850 m	4 m	7,400 m^2	medium
5	21 - 22	550 m	2 m	1,100 m^2	medium
6	24 - 26	675 m	2 m	1,350 m^2	medium
7	49 - 50	400 m	3m	1,200 m^2	medium
8	60 - 63	750 m	5 m	3,750 m^2	medium
9	66 - 68	850 m	1 m	850 m^2	small
10	70 - 73	1,000 m	6 m	6,000 m^2	medium

Table 4. Indian Bayou reaches with estimated mussel densities ≥ 10/m² defined as mussel beds.

Bed Number	Bed Location (Map Numbers)	Estimated Length	Estimated Mean Width	Bed Area	Bed Size
1	05 - 07	600 m	10 m	6,000 m^2	medium
2	10 - 12	950 m	10 m	9,500 m^2	medium
3	14 - 16	950 m	10 m	9,500 m^2	medium
4	19 - 23	900 m	5 m	4,500 m^2	medium
5	26 - 29	950 m	4 m	3,800 m^2	medium
6	31 - 32	600 m	2 m	1,200 m^2	medium
7	35 - 36	450 m	2 m	900 m^2	small

Table 5. Summary of mussels collected during survey of Indian Bayou. FREQ = number of sample sites where species occurred live. AR Conservation Status Rank follows Harris and Posey (2015). Total sites = 38.

Species	TOTAL	% TOTAL	Occurrence	% Occurrence	AR Conservation Status Rank
Amblema plicata	334	13.7	38	100	S5
Arcidens confragosus	81	3.3	25	65.8	S4
Cyclonaias nodulata	18	0.7	14	36.8	S4
Cyclonaias pustulosa	361	14.8	37	97.4	S5
Ellipsaria lineolata	1	<0.1	1	2.6	S4
Eurynia dilatata	249	10.2	27	71.1	S5
Fusconaia flava	400	16.4	35	92.1	S5
Lampsilis cardium	65	2.7	25	65.8	S5
Lampsilis hydiana	17	0.7	8	21.1	S4
Lampsilis teres	12	0.5	10	26.3	S5
Lasmigona complanata	1	<0.1	1	2.6	S4
Leptodea fragilis	11	0.5	11	28.9	S5
Megalonaias nervosa	33	1.4	17	44.7	S4
Obliquaria reflexa	61	2.5	24	63.2	S5
Obovaria arkansasensis	36	1.5	14	36.8	S4
Plectomerus dombeyanus	314	12.9	31	81.6	S4
Potamilus ohiensis	1	<0.1	1	2.6	S4
Potamilus purpuratus	28	1.1	16	42.1	S5
Pyganodon grandis	7	0.3	5	13.2	S5
Quadrula apiculata	8	0.3	6	15.8	S3
Quadrula nobilis	13	0.5	8	21.1	S3
Quadrula quadrula	158	6.5	33	86.8	S4
Toxolasma texasiense	1	<0.1	1	2.6	S3
Tritogonia verrucosa	163	6.7	29	76.3	S5
Truncilla donaciformis	6	0.2	5	13.2	S3
Truncilla truncata	59	2.4	26	68.4	S4
Uniomerus declivis	1D	0.0	1	2.6	S2
Utterbackia imbecillis	3	0.1	3	7.9	S4
Villosa lienosa	1	<0.1	1	2.6	S4
TOTAL	2442	100	38	100	

Table 6. Summary of mussels collected during survey of Big Island Chute. FREQ = number of sample sites where species occurred live. AR Conservation Status Rank follows Harris and Posey (2015). Total sites = 80.

Species	TOTAL	% TOTAL	Occurrence	% Occurrence	AR Conservation Status Rank
Amblema plicata	253	11.1	57	71.3	S5
Arcidens confragosus	38	1.7	25	31.3	S4
Cyclonaias nodulata	48	2.1	28	35.0	S4
Cyclonaias pustulosa	455	19.9	60	75.0	S5
Ellipsaria lineolata	1	<0.1	1	1.3	S4
Eurynia dilatata	11	0.5	8	10.0	S5
Fusconaia flava	261	11.4	52	65.0	S5
Lampsilis cardium	13	0.6	12	15.0	S5
Lampsilis hydiana	1	<0.1	1	1.3	S4
Lampsilis teres	27	1.2	20	25.0	S5
Lasmigona complanata	2	0.1	2	2.5	S4
Leptodea fragilis	63	2.8	35	43.8	S5
Megalonaias nervosa	57	2.5	26	32.5	S4
Obliquaria reflexa	150	6.6	48	60.0	S5
Obovaria olivaria	16	0.7	15	18.8	S3
Plectomerus dombeyanus	100	4.4	37	46.3	S4
Potamilus ohiensis	6	0.3	6	7.5	S4
Potamilus purpuratus	46	2.0	30	37.5	S5
Pyganodon grandis	1	<0.1	1	1.3	S5
Quadrula apiculata	66	2.9	35	43.8	S3
Quadrula nobilis	43	1.9	27	33.8	S3
Quadrula quadrula	541	23.7	59	73.8	S4
Reginaia ebenus	2	0.1	1	1.3	S5
Tritogonia verrucosa	37	1.6	23	28.8	S5
Truncilla donaciformis	4	0.2	4	5.0	S3
Truncilla truncata	35	1.5	19	23.8	S4
TOTAL	2284	100	70	87.5	

Table 7. Big Island Chute reaches with estimated mussel densities ≥ 10/m² defined as mussel beds.

Bed Number	Bed Location (Map Numbers)	Estimated Length	Estimated Mean Width	Bed Area	Bed Size
1	11 - 12	450 m	3 m	1,350 m^2	medium
2	15	450 m	2 m	800 m^2	small
3	19 - 21	550 m	4 m	2,200 m^2	medium
4	26 - 33	2,000 m	4 m	8,000 m^2	medium
5	35 - 36	150 m	8 m	1,200 m^2	medium
6	38 - 41	650 m	6 m	3,900 m^2	medium
7	42 - 43	450 m	3 m	1,350 m^2	medium
8	55 - 60	1,500 m	6 m	9,000 m^2	medium
9	63 - 65	500 m	5 m	2,500 m^2	medium
10	69 - 71	850 m	2 m	1,700 m^2	medium
11	71 - 73	450 m	2 m	900 m^2	small

Table 8. LaGrue Bayou reaches with estimated mussel densities ≥ 10/m² defined as mussel beds.

Bed Number	Bed Location (Map Numbers)	Estimated Length	Estimated Mean Width	Bed Area	Bed Size
1	08 - 09	500 m	10 m	5,000 m^2	medium
2	12 - 14	500 m	10 m	5,000 m^2	medium
3	16 - 17	175 m	3 m	525 m^2	small
4	31 - 35	750 m	2 m	1,500 m^2	medium
5	38 - 40	400 m	2 m	800 m^2	small
6	46 - 48	500 m	5 m	2,500 m^2	medium
7	54 - 56	350 m	6 m	2,100 m^2	medium

Table 9. Summary of mussels collected during survey of LaGrue Bayou. FREQ = number of sample sites where species occurred live. AR Conservation Status Rank follows Harris and Posey (2015). Total sites = 58.

Species	TOTAL	% TOTAL	Occurrence	% Occurrence	AR Conservation Status Rank
Amblema plicata	338	13.0	50	86.2	S5
Arcidens confragosus	74	2.8	38	65.5	S4
Cyclonaias nodulata	137	5.3	39	67.2	S4
Cyclonaias pustulosa	177	6.8	45	77.6	S5
Fusconaia flava	91	3.5	34	58.6	S5
Lampsilis cardium	3	0.1	3	5.2	S5
Lampsilis hydiana	2	0.1	2	3.4	S4
Lampsilis teres	16	0.6	13	22.4	S5
Leptodea fragilis	12	0.5	12	20.7	S5
Megalonaias nervosa	62	2.4	28	48.3	S4
Obliquaria reflexa	183	7.0	46	79.3	S5
Obovaria arkansasensis	6	0.2	3	5.2	S4
Plectomerus dombeyanus	116	4.5	40	69	S4
Potamilus ohiensis	3	0.1	3	5.2	S4
Potamilus purpuratus	23	0.9	18	31	S5
Pyganodon grandis	7	0.3	7	12.1	S5
Quadrula apiculata	61	2.3	24	41.4	S3
Quadrula nobilis	175	6.7	47	81	S3
Quadrula quadrula	1052	40.5	54	93.1	S4
Reginaia ebenus	1	<0.1	2	3.4	S5
Tritogonia verrucosa	21	0.8	17	29.3	S5
Truncilla donaciformis	4	0.2	3	5.2	S3
Truncilla truncata	34	1.3	23	39.7	S4
TOTAL	2598	100	56	96.6	

Table 10. Percent composition (dominance rank) comparison for species >10% of total sample. White River bed data (n = 10) from Christian (1995). Blue highlights species with highest percent composition, magenta highlights species with second highest percent composition.

Species	Maddox Bay	Indian Bayou	Big Island Chute	LaGrue Bayou	White River Beds
Amblema plicata	19.3 (2)	13.7 (3)	11.1 (4)	13.0 (2)	0.0-3.0
Cyclonaias pustulosa	6.4 (6)	14.8 (2)	19.9 (2)	6.8 (4)	0.9-15.2
Eurynia dilatata	1.2 (14)	10.2 (5)	0.5 (19)	0.0 (NA)	0.0-0.6
Fusconaia flava	14.7 (3)	16.4 (1)	11.4 (3)	3.5 (8)	0.0-0.5
Leptodea fragilis	0.3 (18)	0.5 (17)	2.8 (8)	0.5 (16)	2.2-38.9
Plectomerus dombeyanus	7.6 (4)	12.9 (4)	4.4 (6)	4.5 (7)	0.4-8.1
Quadrula quadrula	22.0 (1)	6.5 (7)	23.7 (1)	40.5 (1)	20.7-44.8

DATA APPENDICES

Appendix A-1 - Summary Table of Collection Sites - Maddox Bay

Appendix A-2 - Field Data Sheets (Chronological Order) - Maddox Bay

Appendix B-1 - Summary Table of Collection Sites - Indian Bayou

Appendix B-2 - Field Data Sheets (Chronological Order) - Indian Bayou

Appendix C-1 - Summary Table of Collection Sites - Big Island Chute

Appendix C-2 - Field Data Sheets (Chronological Order) - Big Island Chute

Appendix D-1 - Summary Table of Collection Sites - LaGrue Bayou

Appendix D-2 - Field Data Sheets (Chronological Order) - LaGrue Bayou